JOURNAL

OF THE

FRANKLIN INSTITUTE.

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXIX. JANUARY, 1885. No. 1.

THE Franklin Institute is not responsible for the statements and opinions advanced by contributors to the JOURNAL.

THE DIVINING-ROD.*

BY ROSSITER W. RAYMOND, PH.D., New York City.

[A lecture delivered at the International Electrical Exhibition, September 18, 1884.]

The extent to which the divining-rod is still used in this country for the detection of hidden treasure, mineral veins, or springs, is much greater than educated persons would be likely to suppose. For many years wells have frequently been located by its aid in New England, where the belief is widely extended among the farmers that in the hands of peculiarly gifted persons this instrument possesses special virtue. Large numbers of the oil wells of Pennsylvania have been bored at points designated by the so-called "oil-smellers." More than one adept with this instrument is practising now in the Western mining region. I encountered, a few months ago, in Southern Colorado, a party of capitalists who were accompanied by such an expert, and whose purpose was to discover a mine, by his aid, and to buy the property thus made valuable. Still more recently, a paragraph in the Tombstone *Epitaph*, of Arizona, announced that a party of gentlemen from Chicago, whose names were given, had been scouring over the hills in the neighborhood of Tombstone, for more than a week, in

* This lecture was originally presented as a paper before the American Institute of Mining Engineers, and is here republished, by permission, from the Transactions of that Society, vol. xi.

company with an expert of Colorado, who had been employed to ascertain "with his well-known divining-rod" the localities of mineral wealth, and who had declared the existence of large bodies of ore in at least two places not yet developed. It is also reported, with what truth I do not know, that the Central Pacific and Southern Railroad companies have employed the divining-rod successfully in the discovery of water, and have located by this means their artesian wells in the desert. Last, but not least, a small book entitled *The Divining Rod*, and published in Cleveland, in 1876, contains an essay on this subject, read before the Civil Engineers' Club, of the Northwest, at Chicago, in 1875, by Mr. Charles Latimer, a well-known engineer who has had charge of several important railways, and who testifies in the most unqualified manner to the virtues of the divining-rod as a means of determining the position and the depth of subterranean water-courses, and claims to have discovered certain new and important laws of its operation connecting if not identifying it with the force of electricity.

These circumstances, taken together with the fact that the "dowsers," or experts with the rod, still enjoy considerable local authority in Cornwall, and that believers in its efficacy may still be encountered among the German miners (although I think in that country the faith is more nearly extinct than elsewhere), certainly justify me in regarding this subject as one not solely of historical interest. Yet a consideration of its history and literature will throw important light upon the question, whether the phenomena which it has presented, and continues to present, are to be ranked under the head of self-delusion, deliberate deceit, or both; or, on the other hand, indicate, after all reasonable deductions for human error and credulity, a residuum of important scientific truth.

Before sketching the history of this instrument, it will be well to say a few words concerning its form, material, and use. Yet this is a work of no little difficulty. The immense literature of the divining-rod shows nothing more clearly than the boundless confusions and contradictions of its advocates and professors. Of the dozen different schools of practice, each is necessarily obliged to reject many of the asserted principles and certified facts put forward by the rest.

The most common divining-rod, perhaps, has always been a forked branch of witch-hazel in the shape of the letter Y. This wood may have been selected because it forks in such a way as to give two branches of equal size, or because of its supposed affinity for springs of water.

But other woods, such as peach, ash, pitch-pine, and even metals, have been recommended at different times, and different professors of the art have also varied the shape of the rod, employing sometimes a straight twig with a small fork only at one end, or an elastic twig or whalebone without any fork. The dowsing-rod used by the expert mentioned in the Tombstone *Epitaph*, is, I believe, an instrument made of two prongs of whalebone united in a stem which terminates in a case similar to a rifle-cartridge. The contents of this case are a secret. (Similar cases, used in the Middle Ages, are said to have contained mercury.) This rod, like the ordinary forked hazel switches, is held in the two hands, each grasping the extremity of a prong, with the fingers closed not too tightly and the palms upward, the shank or stem of the rod being horizontal or vertical, or variously inclined, according to the principles of the practitioner. When carried in this manner by the operator, walking over the surface of the ground, the rod is said to turn or dip above treasure, mineral veins, springs, etc.; but there is an elaborate and complicated science based upon the various degrees, directions, and force of this dipping. Unfortunately the rules as determined by one or another celebrated operator have been found not to work for his rivals or successors, so that each authority lays down rules of its own. The straight rods were either balanced in various ways on one or both hands, or sprung bow-like between the two hands. The most peculiar rod described in ancient books was made of two pieces of wood, one of which was pointed and the other provided in the end with a socket. This rod being delicately held was said to indicate the presence of the object sought for by a peculiar revolution of the point in the socket.

An inquiry into the uses of such rods leads us at once to the history of our subject, in the study of which it will appear that divining-rods were first used in antiquity mainly or wholly for moral purposes; that in the Middle Ages their employment was for a long period confined to the discovery of material objects; that towards the end of the seventeenth century the moral use was again asserted, and that in the eighteenth century the divining-rod was relegated to the material sphere, and assumed the comparatively modest functions in the discharge of which it still lingers among us.

I would recommend to those who have not the means of an extended research the perusal of the book of Professor Fiske, of Harvard, on *Myths and Myth-makers* (Boston, 1873), in the second essay of which,

on *The Descent of Fire*, this subject is treated in the light of comparative mythology; also the work of Louis Figuier, *Histoire du Merveilleux dans les Temps Modernes* (Paris, 1860), half of the second volume of which is devoted to the divining-rod; and, finally, the book of Chevreul, *La Baguette Divinatoire* (Paris, 1853), which is a conclusive summary from the standpoint of modern science and experiment. I do not mention the work of Mr. Baring-Gould, *Curious Myths of the Middle Ages*, which Professor Fiske compliments with frequent quotations, for the simple reason that Mr. Baring-Gould's essay on the divining-rod is made up almost wholly of portions of Figuier's work, often translated *verbatim* and without credit. A brief, interesting, and impartial discussion of the divining-rod from the standpoint of the Middle Ages, together with a curious engraving illustrating its use, will be found in the well-known work of Agricola (*De Re Metallica*, Basle, 1546), published in the sixteenth century both in Latin and in German, copies of which, though not very common, are still to be met with in the antiquarian bookstores of Europe. I believe the Library of the School of Mines, of Columbia College, contains a German copy. In the preparation of this paper I have made use of the Latin edition, which is the only one in my possession. An excellent summary of the subject, containing many curious details, will be found also in Professor Moritz Gaetzschmann's *Auf-und Untersuchung der Lagerstätten* (Freiberg, 1857). The Brooklyn Library contains a copy of a work entitled *Jacob's Rod: A Translation from the French of a Rare and Curious Work, A. D.* 1693, *on the Art of Finding Springs, Mines, and Minerals by means of the Hazel Rod. To which is Appended Researches with Proofs of the Existence of a More Certain and Far Higher Faculty, with Clear and Ample Instructions for Using it.* Published by the Translator: Thomas Welton, 13 Grafton street, Fitzroy Square, London. This book was published, I believe, in 1875. The title-page bears no date. The original French treatise, the translation of which occupies the first part, is probably the one entitled *La Verge de Jacob, ou l'Art de trouver les trésors*, which Figuier (*Histoire*, etc., vol. ii., p. 257) speaks of as well-known to the adepts in occult sciences, and Chevreul (*La Baguette*, etc., p. 30) mentions as an example of the use of the term "Jacob's rod," in those sciences, to signify a rod possessing marvellous properties. The origin of this signification will be found in Genesis, xxx. I suspect that neither Figuier nor Chevreul had seen this book; both of them fail to give either the name of the author or

the date of publication, an omission especially noticeable in the case of Chevreul, who is usually both full and careful in his references. The translator gives the date as 1693, and names the author as M. Baritel. Of the fidelity of the translation I have no guaranty except internal evidence, from which I judge that it is honest rather than intelligent. This translator, Mr. Walton, is himself a mesmerist and electro-biologist, and declares his wife to be possessed of clairvoyant powers, of the exercise of which he believes the discovery of water, metals, etc., to be but one sub-division. The object of his translation and "addenda" is to connect the ancient phenomena of rhabdomancy, the observations and theories of Reichenbach, the fanciful speculations of Bulwer-Lytton, and numerous modern wonders (accounts of which he extracts from the *Spiritual Magazine*), and his own and his wife's alleged experience.

To the works above named I am indebted for nearly all the facts cited in this paper, and for many quotations made at second hand.

Professor Fiske, following Dr. Kuhn, whose treatise on the *Descent of Fire* was published in Berlin in 1859, traces the divining-rod to a wide-spread Aryan myth, connected with the forked lightning. Without going so far back, we may find in written history many evidences of the use of the rod, not only as a symbol of earthly power, but also as the instrument of supernatural effects, and particularly of divination. It will be remembered that the Egyptian sorcerers confronted by Moses carried rods, as Moses and Aaron also did. The prophet Hosea denounces the use of rods for divination by the Jews (Hosea 4:2). According to another prophet (Ezekiel 21:26) the King of Babylon consulted rods or arrows to decide his course. The Scythians, Persians, and Medes used them. Herodotus says that the Scythians detected perjurers by means of rods. The word *Rhabdomancy*, originated by the Greeks, shows that they practised this art; and the magic power of the rods of Minerva, Circe, and Hermes or Mercury, is familiar to classical students. The *Lituus* of the Romans, with which the augurs divined, was apparently an arched rod. Cicero, who had himself been an augur, says in his treatise on divination, that he does not see how two augurs, meeting in the street, could look each other in the face without laughing. At the end of the first book of this treatise he quotes a couplet from the old Latin poet Ennius, representing a person from whom a diviner had demanded a fee as replying to this demand, "I will pay you out of the treasures which you

enable me to find." This ancient joke, by the way, has been adopted in all seriousness by the "oil-smellers" of Pennsylvania, who, as I am informed, are accustomed to locate oil wells on precisely this condition, receiving nothing if the well proves unsuccessful, and fifty dollars if oil is struck.

Marco Polo reports the use of rods or arrows for divination throughout the Orient, and a later traveler describes it among the Turks. Tacitus says that the ancient Germans used for this purpose branches of fruit-trees. One of their tribes, the Frisians, employed rods in church to detect murders. Finally, if we may trust Gonsalez de Mendoza, the Chinese, who seem to have had everything before anybody else, used pieces of wood for divination.

Thus we perceive that the application of the divining-rod in historical antiquity was mainly or wholly moral; that is, it was employed to detect guilt, decide future events, advise courses of actions, etc. There are but two passages which have been quoted to prove its use for physical purposes: one from Ctesias (*apud. phot. bibl. cod.*) who speaks of a rod of the wood *Parebus*, which attracted gold, silver, other metals, stones and several other things; the other from Cicero (*De Officiis*, lib. i.) who says, "If we could obtain with the so-called divine rod everything pertaining to food and clothing" (*ad victum cultumque*), etc.

On the other hand, the silence of many authors is significant, as Chevreul has pointed out. Varro does not mention the use of the rod for the discovery of subterranean waters or metal. Vitruvius, discussing the means of discovering springs, says nothing of it. Pliny, in Book xxx. of his Natural History, omits it from his enumeration of magical arts and methods, and in Book xxxi., describing (after Vitruvius) the means of discovering springs and in Book xxxiii., describing explorations for metals, is equally silent concerning it. Columella, Palladius and in the sixth century Cassiodorus are likewise dumb, though the latter in one of his epistles (*Thodoric*, liii.) extols the utility of the professional water-discoverers. Even as late as 1569, a book printed in Orleans (*L'art et science de trouver les eaux et fontaines cachées sous terre autrement que par les moyens vulgaires des agriculteurs et architectes*, par Jacques Besson, Dauphinois, mathematicien) contains no allusion to the rod. It is a curious circumstance that this work emanated from Dauphiny, the home, a century later, of the most famous diviners and water-discoverers.

But the alchemistic literature brings the physical uses of the divining-rod to the front. The first mention is usually credited to the *Novum Testamentum* of Basil Valentin, a Benedictine monk and hermeneutic philosopher of the 15th century. But it must be remembered that the existence, even, of this man is not beyond doubt. It is attested by Gadenus (*Historia Erfordiensis*, 1675), who says that Basil was living at the convent of St. Peter's at Erfurth in 1413. Yet the *Testamentum* was actually first printed at the beginning of the 17th century, though manuscript copies had been circulated earlier. Of these, Chevreul possesses one (a French translation) dated 1651, and from it quotes the famous passage according to which, at the time of the writer, the divining-rod was worn in the belt or the hat and was used to discover metals. Basil describes seven varieties of the rod, according to its different motions.

Whatever its antiquity, the use of the rod to discover hidden treasure or metallic ore became general in Germany, and was extended thence through Flanders, England, Sweden, France, Italy and Spain, before the end of the 17th century. It must be remembered that in those days the practice of burying money and plate was universal. A rod that would discover buried treasure only would, at the present time, be of comparatively little value. We know well enough where the large masses of gold and silver are piled. It is not ignorance, but bolts and bars, that prevent our getting at them; and a large class of the diviners of the Middle Ages would be obliged, if they lived to-day and practised their profession, to become burglars or cashiers.

The scientific explanation of the divining-rod at this period, like the scientific explanation of nearly all facts in chemistry and physics, was "affinity," a word under which was concealed a little science together with a vast amount of ignorance and superstition. Philip Melanchthon (1497–1560), the friend of Luther, adopted this theory to explain the effects of the divining-rod. We must confess that in an age when the attraction of the magnet for iron and of electrified amber for light bodies was known, but not understood, there was no necessary absurdity in supposing that similar phenomena might be exhibited by other classes of substances. And this natural presumption, joined with the inherent credulity of ignorance and the tendency to generalize upon imperfect data, caused a very general acceptance of the alleged operations of the divining-rod as true, and consequently the promulgation of crude quasi-scientific theories to account for it. On the other hand,

it must be remembered that the belief in demonic agencies was still active and all-pervading, so that when facts could not be scientifically explained they were at once referred to witchcraft or to the devil direct. So long as the discussion remained within the field of science it was conducted with courage and candor; but when it entered the demonic domain, the boldest philosopher, unless he were willing to sell his soul to Satan, became dumb. This may explain the attitude of the great Agricola (*De Re Metallica*, lib. ii.), a keen observer and wise reasoner, who, after saying that the alleged virtues of the divining-rod are subject to much dispute, and stating both sides of the dispute with admirable clearness, demolishes in a few words the supposed analogies of magnetism and electricity, but declares that if the divining-rod derives any power from spells and incantations, that is a matter neither permissible nor agreeble for him to discuss. He proceeds, moreover, to assert as the general result of experience in his time that the professors of the divining-rod, though they sometimes succeed in discovering veins, quite as frequently fail, and have to dig like other people if they wish to find anything. Wherefore, he advises the respectable and sober miner to study the indications of nature, and then dig at once, without further fooling. In the quaint woodcut which accompanies this passage a miner is represented in the background as cutting his hazel twig; while another in the foreground is proceeding with it in due form for the discovery of the mine; and (whether in sarcasm or not, I do not undertake to say) at the very point to which the latter is steering, two of Agricola's "good and sober" miners have already found ore by the homely process of digging.

Paracelsus (1495–1541) condemns in his works, as uncertain, illusory and unlawful, the use of the rod. His disciples did not uniformly agree with this view. Goclenius, author of *Essays on the Virtue of Plants and the Unguent of Arms*, believes in the efficacy of the rod and does not condemn its use. Libavius, author of the *Syntagma arcanorum chimicorum* (died 1616) believed in it from experience, and explains its action by sympathetic affinity. This theory, already announced by Melanchthon, was also held by his son-in-law Peucer, by Porta (*Magia Naturalis*, 1569, lib. xx., cap. viii.), by Keckermann (1573–1609, *Systemata Physica*, lib. i., cap. viii.) by the author of one of the discourses published with those of Maiolus, Bishop of Volturara (1614) and by Michael Mayer, the prolific author of alchemistic allegory (*Verum inventum, hoc est Munera Germaniæ*, cap. iv.) who, de-

scribing the invention of gunpowder in Germany and the use of hazel-charcoal in its original manufacture, mentions the sympathy which hazel-wood has for metals, and its consequent employment in the form of the divining-rod.

On the other hand, the Jesuit father Laurentius Forer (*Viridarium philosophicum seu disputationes de selectis in philosophiâ materiis*, 1624) condemns the use of the rod as a superstitious practice. We must distinguish therefore three different views of the question; two of which accepted the efficacy of the rod as proved, and ascribed it respectively to a physical property of the rod, and to demonic agency, while the third discredited the alleged facts, and pronounced the practice to be a superstition.

A fourth view was indeed advanced, according to which the operator, as well as the rod, was the recipient of a divinely-given faculty. It was no doubt with the purpose of avoiding the odium attached to dealings with the Evil One that the professors of this science, particularly in Germany, surrounded it with ceremonies and formulas of a highly pious character. It is true that the rules sometimes prescribed for the cutting of the twig partook largely of heathen sorcery and astrology. They were indeed, to some extent, unconscious reminiscences of the old Scandinavian, and even of the Aryan, mythology. But this was atoned for when the rod was duly Christianized by baptism, being laid for this purpose in the bed with a newly baptized child, by whose Christian name it was afterwards addressed. The following formula, cited by Gaetzschmann, may serve as an example. "In the name of the Father, and of the Son, and of the Holy Ghost, I adjure thee, Augusta Carolina, that thou tell me, so pure and true as Mary the Virgin was, who bore our Lord Jesus Christ, how many fathoms is it from here to the ore?" In this case, the rod was expected to reply by dipping a certain number of times, corresponding to the number of fathoms.

Such devices, however, were not everywhere successful in diverting from the practitioners of this occult science the evil name of sorcery. A striking and pathetic instance is furnished in the seventeenth century by the history of the Baron and Baroness Beausoleil. The Baron, born in Brabant, devoted himself to mineralogy and mining, and became, undoubtedly, one of the foremost mine-engineers of his time. He visited and studied the mines of Germany, Hungary, Bohemia, Tyrol, Silesia, Moravia, Poland, Sweden, Italy, Spain, Scotland, Eng-

land and France. The emperors Rudolph and Matthias appointed him counsellor and commissary-general of the mines of Hungary. The archduke Leopold made him director of the mines of Tyrol and Trent. The dukes of Bavaria, Neuburg, and Cleves gave him the same title. Finally, the Pope did the same for all the papal states. He appears to have amassed from these various employments a considerable fortune.

In 1600 he was engaged by the comptroller-general of the mines of France to open mines in Languedoc and some other provinces, and in 1626 this commission was still further extended. During this period he met and married his wife, who devoted herself with enthusiasm to his profession, studying and traveling extensively with him in Germany, Italy, Sweden, and perhaps Spain. They even made a voyage to the shores of the New World. In 1627 their house was robbed under the legal forms of search on the charge of sorcery preferred by a local official. Their loss was estimated at one hundred thousand crowns. They easily obtained acquittal of the charge; but it is an instructive commentary on the justice of the time that they never were able to recover their property. They went to Hungary, but returned to France in 1632 under a new commission from Louis XIII. In this year the baroness, who was an accomplished author, published an account of one hundred and fifty mines already discovered in France, and of some medicinal springs. They expended, in further explorations, nearly the whole of their fortune, but were unable, in the face of their jealous rivals and enemies, to obtain from the government the grants which had been promised them, and by means of which they expected to reimburse themselves. Finally, the baroness published a work, addressed to Richelieu, and entitled *The Restitution of Pluto* (reprinted at Paris in 1779), in which, with eloquent indignation, she declared the deserts of her husband and herself, and asserted their right to the rewards promised them, urging the cardinal-minister at the same time, by every consideration of the glory and greatness of France, to encourage the development of its mineral resources. Unfortunately, in this work she furnished new material for the slanderous accusation of sorcery. In magnifying the art of discovering mines and springs, and the skill required for this purpose, she gives a description of the means employed, showing that these hidden treasures are to be detected,

1. By digging, which is the least important way;
2. By the herbs and plants which grow above springs of water;
3. By the taste of the waters which flow from them;
4. By the vapors which arise from them at sunrise;
5. By the use of sixteen scientific instruments and of seven rods (the seven rods of Basil Valentin) connected with the seven planets, etc.

The first four means were undoubtedly real and really employed. Under the fifth head we have an illustration of what is so common in the alchemistic and other mediæval writers, namely, the covering of the facts of nature and the methods of investigation with assumed mystery, to hide them from the vulgar. So long as the baron and baroness were spending their own money for the good of the State, they were permitted to go on, and even received complimentary notices from time to time, which, indeed, could not be withheld from persons of such eminent reputation. But when they became troublesome in their demands for more substantial favors and came into collision with the "rings" which infested the kingdom, the charges of sorcery renewed against them furnished a convenient pretext for putting them ont of the way. Richelieu may even have supposed that he was behaving in this case with lenity, since instead of having them burned to death, as he did with another sorcerer of the same period, he only put the baron in the Bastile (1642) and his wife in Vincennes, where they soon (about 1645) died in destitution and misery, victims not so much of the superstition as of the corruption of the times.

It will be noted that the treatise of the baroness did not claim from the divining-rod any moral virtue. What the Beausoleils appear to have done for this instrument was to bring forward its use in the discovery of springs as well as metals. The literature of that period seems to ignore in the main any powers of the rod in prophecy or moral discrimination.

The Jesuit father Cæsius (*Mineralogia*, 1636) inclines to deny the efficacy of the rod.

Robert Fludd (*Philosophia moysaica*, 1638) after mentioning the sympathy existing between the crab or oyster and the moon, between the rue and the fig-tree, between myrtle and the pomegranate, adduces as an instance of similar sympathy between plants and minerals the dipping of a hazel-rod over a vein of silver or gold.

The celebrated chemist, Rudolph Glauber (*Pars seconda Operis min-*

eralis, 1652) affirms from experience, and attributes to a physical property, the efficacy of the rod in exploring for metals.

The Jesuit father, Jean François (*Science des Eaux*, 1653) seems to admit the power of the rod to discover springs, but condemns its use.

The erudite Jesuit father, Kircher (*De Arte Magnetica*, 1654, *De Mundo Subterraneo*, 1678) having proved by experiment that rods of wood alleged to be sympathetic with certain metals, were, when balanced upon pivots, not at all affected by the proximity of these metals, concluded that the sympathy was chimerical. In his later work he declared roundly that if the movement of the rod did not proceed from a joke or a cheat on the part of the operator, it was not natural, and ridiculed those who fancied it could be caused by a vapor disengaged from the metal.

Edo Neuhusius (*Sacrorum fatidicus*, 1658) believes in the working of the rod, and attributes it to a sympathy, or to the stars, or some other cause.

The Jesuit father, Gaspard Schott (*Physica curiosa*, 1662), pronounces the use of the rod superstitious, or rather diabolical. But he adds in a footnote that pious and honest men have assured him both with regard to the turning of the rod and with regard to the striking of the hours by a ring suspended within a glass (*pulsum annuli filo intra scyphum suspensi et horas indicantis*), that the experiment does not always succeed, and hence he will not assert that the demon is always acting. The argument appears to be, that if the devil had it in hand, it would not fail. The pious and honest men aforesaid also protested that the phenomenon was natural and not due to fraud or fancy. "*Sed nondum persuaserunt*," pithily concludes Schott. The passage is noteworthy as containing a reference to the wonderful pendulum, which became, at a later day, the subject of scientific treatises, and still survives as a puzzle and amusement for children for all growths.

Sylvester Rattray (*Theatrum sympatheticum*, 1662) believes in the sympathy of vegetables with minerals. According to him, the hazel is suitable for the discovery of silver, wild pine for lead, olive and palm for gold and silver.

It was in 1666 that Robert Boyle put the question as a member of the Royal Society of London, whether the divining-rod is really moved by the proximity of metal—a pertinent inquiry which no one seems to have answered by authoritative and thorough experiments, unless we

may accept as sufficient those of Kircher above mentioned. The accumulation of contradictory testimony from witnesses of all degrees of competency went on.

Matthias Willenius, a German author, published in 1671 or 1672 a book called *A True Account of the Rod of Mercury*, in which, as the title indicates, he appealed to astrology for the partial explanation of his theme, asserting that the influence of the stars under which the operator is born, contributes to the turning of the rod over metals, "by the effect of the harmony established between heaven and earth."

Frommann (*Tractatus de fascinatione*, 1674) says that, after long hesitation, he has decided that the use of the rod is lawful.

The Jesuit father, Dechales (*De Fontibus naturalibus*, 1674), inclines to the same opinion, and speaks of the hazel as having been in all times (*omni tempore*) used as an index to springs. This is a curious illustration of the rapidity with which a tradition may come to be considered immemorial. In fact, if we except the striking of the rock in the desert by Moses—which is certainly not a case in point—the first trace of the use of the rod for discovering springs, is in the works of the Beausoleils, scarcely fifty years before Dechales wrote his treatise.

Le Royer, a lawyer of Rouen, published in 1674 his *Traité du bâton universal*, and in 1677 his *Traité des influence et des vertus occultes des êtres terrestres*. He declares that the rod by its sympathetic virtue can discover all hidden objects, metals, springs, etc. But he ascribes to it no moral power.

The Abbé Hirnhaïn (*De typho generis humani, sive scientiarum humanarum inani ac ventoso humore*, etc., 1676) while scoffing at many received beliefs, admits without question the efficacy of the divining-rod.

St. Romain (*La Science naturelle degagée des chimères de l'école*, 1679) was one of the first believers in the rod to reject the sympathies and antipathies and to substitute the Cartesian corpuscular hypothesis—of which I shall have more to say hereafter.

Finally, the celebrated botanist, Ray (*Histoire des Plantes*, 1686), classed the divining-rod among superstitions.

This review of the literature of the subject has brought us to the end of an important period, namely, that in which the physical effects of the rod were exclusively discussed, its earlier uses for general divination having gone out of fashion and recollection. Indeed, any attempt to maintain these would have incurred the censure of the church, which would have settled at once the vexed question of agency by denouncing

this unauthorized intrusion upon its spiritual prerogative as diabolic. This is indeed what speedily happened, as we shall see. The lost doctrine of moral power reappeared, not among the learned, but out of the obscure mass of the people. In the province of Dauphiny, in the south of France, the practice of the divining-rod, introduced perhaps by the Beausoleils, had become, fifty years after their death, an art followed by many experts, who were called *Hommes à Baguette.* They were employed to find springs of water, hidden treasure, mines, etc., and also to detect criminals, and even to settle disputes as to boundaries when the landmarks were gone. Two farmers, for instance, having a dispute as to the boundary between their farms, instead of going to a lawyer or judge, would send for a diviner. He walking over the disputed ground, would indicate by the dipping of his rod the spot where the old landmark formerly stood; and this decision was accepted without appeal. Considering the expense of litigation in all times, and the peculiar character of the justice which at that time was sold so dear and worth so little, we may fairly say that whatever be the merits of the divining-rod, the peasants of Dauphiny acted wisely in employing it.

In 1692 a mysterious murder was committed at Lyons. A wine merchant and his wife were found dead, lying in their cellar near the bloody axe with which they had been slain. A neighbor urged the authorities (who seem to have had no clue to the murderers) to employ a rich peasant of Dauphiny, already famous as an expert with the divining-rod. This man, Jacques Aymar by name, was sent for—or rather it was not necessary to send for him, since he proved to be already on hand in the city, by the time it was decided to engage his services. This fact is significant, as giving the key to what turned out to be an extraordinary piece of clever detective work. A careful analysis of the numerous official and other records of this case shows it to be quite possible that the diviner had obtained important clues before he was publicly set to work. He first demanded to be taken to the scene of the crime that he might get his "impression." This consisted in a sort of shuddering, accompanied with signs of agitation, pain and exhaustion, and manifesting itself besides in the dipping of his rod. This took place at the spot where the bodies had lain, the spot where the axe was found, and also in the shop above, at various points which he declared to have been occupied or touched by the criminals. Having thus obtained a thorough impression, after the fashion of a blood-

hound getting a scent, he started, though it was night, and followed with his rod the alleged course of the fugitives, passing without hesitation through many unlikely places, as far as one of the gates of the city. Next morning he resumed the trail and tracked it to the house of a gardener, where he declared that the criminals, either two or three in number, had stopped. The gardener and his wife denied all knowledge of them, and Aymar, consulting his rod, declared that neither had touched the murderer. But the rod dipped violently over two young children of the house, who thereupon confessed that three men had stopped there the day before, and had drunk wine at a table, which, by the way, had also been indicated by the rod. The children said they had kept this a secret because they feared being punished for leaving the door unlocked while their parents were away. After some further delays and preliminary tests, the magistrates determined to let Aymar pursue the murderers. He declared that they had taken a boat down the Rhone, and he followed them with an escort in the same manner, landing from time to time at different points where he said they had stopped. His pursuit was continued for a number of days with various interruptions, the assigned causes of which seem to have been sometimes but pretexts, and permit the suspicion that the intervals were employed by him in getting information in other ways. However this may be, he finally brought up at the prison of Beaucoire, and after applying his rod in succession to the inmates, pointed out as one of the Lyons murderers a hunch-back, recently arrested for larceny. This man, being taken back to Lyons, was recognized at several points on the road as having passed just after the murder, and finally, frightened by the accumulated evidence against him, made a full confession, and was subsequently broken alive. The other two murderers Aymar professed to follow to the sea and at sea along the coast, until, as he alleged, they escaped from the kingdom.

So long as there was no doubt of Aymar's sincerity, this discovery of the criminal by the aid of the divining-rod seemed indeed marvelous. But it is not more wonderful than many detective operations in which the rod has placed no part; and it is easy to trace the possible or probable methods which he employed. If, for instance, during the period just preceding his engagement by the magistrates, he had, in coming to town from his residence, fourteen leagues distant, or in hanging about the town, where everybody was talking of the crime, picked up in any way the circumstances of the three fugitives entering

this unauthorized intrusion upon its spiritual prerogative as diabolic. This is indeed what speedily happened, as we shall see. The lost doctrine of moral power reappeared, not among the learned, but out of the obscure mass of the people. In the province of Dauphiny, in the south of France, the practice of the divining-rod, introduced perhaps by the Beausoleils, had become, fifty years after their death, an art followed by many experts, who were called *Hommes à Baguette.* They were employed to find springs of water, hidden treasure, mines, etc., and also to detect criminals, and even to settle disputes as to boundaries when the landmarks were gone. Two farmers, for instance, having a dispute as to the boundary between their farms, instead of going to a lawyer or judge, would send for a diviner. He walking over the disputed ground, would indicate by the dipping of his rod the spot where the old landmark formerly stood; and this decision was accepted without appeal. Considering the expense of litigation in all times, and the peculiar character of the justice which at that time was sold so dear and worth so little, we may fairly say that whatever be the merits of the divining-rod, the peasants of Dauphiny acted wisely in employing it.

In 1692 a mysterious murder was committed at Lyons. A wine merchant and his wife were found dead, lying in their cellar near the bloody axe with which they had been slain. A neighbor urged the authorities (who seem to have had no clue to the murderers) to employ a rich peasant of Dauphiny, already famous as an expert with the divining-rod. This man, Jacques Aymar by name, was sent for—or rather it was not necessary to send for him, since he proved to be already on hand in the city, by the time it was decided to engage his services. This fact is significant, as giving the key to what turned out to be an extraordinary piece of clever detective work. A careful analysis of the numerous official and other records of this case shows it to be quite possible that the diviner had obtained important clues before he was publicly set to work. He first demanded to be taken to the scene of the crime that he might get his "impression." This consisted in a sort of shuddering, accompanied with signs of agitation, pain and exhaustion, and manifesting itself besides in the dipping of his rod. This took place at the spot where the bodies had lain, the spot where the axe was found, and also in the shop above, at various points which he declared to have been occupied or touched by the criminals. Having thus obtained a thorough impression, after the fashion of a blood-

hound getting a scent, he started, though it was night, and followed with his rod the alleged course of the fugitives, passing without hesitation through many unlikely places, as far as one of the gates of the city. Next morning he resumed the trail and tracked it to the house of a gardener, where he declared that the criminals, either two or three in number, had stopped. The gardener and his wife denied all knowledge of them, and Aymar, consulting his rod, declared that neither had touched the murderer. But the rod dipped violently over two young children of the house, who thereupon confessed that three men had stopped there the day before, and had drunk wine at a table, which, by the way, had also been indicated by the rod. The children said they had kept this a secret because they feared being punished for leaving the door unlocked while their parents were away. After some further delays and preliminary tests, the magistrates determined to let Aymar pursue the murderers. He declared that they had taken a boat down the Rhone, and he followed them with an escort in the same manner, landing from time to time at different points where he said they had stopped. His pursuit was continued for a number of days with various interruptions, the assigned causes of which seem to have been sometimes but pretexts, and permit the suspicion that the intervals were employed by him in getting information in other ways. However this may be, he finally brought up at the prison of Beaucoire, and after applying his rod in succession to the inmates, pointed out as one of the Lyons murderers a hunch-back, recently arrested for larceny. This man, being taken back to Lyons, was recognized at several points on the road as having passed just after the murder, and finally, frightened by the accumulated evidence against him, made a full confession, and was subsequently broken alive. The other two murderers Aymar professed to follow to the sea and at sea along the coast, until, as he alleged, they escaped from the kingdom.

So long as there was no doubt of Aymar's sincerity, this discovery of the criminal by the aid of the divining-rod seemed indeed marvelous. But it is not more wonderful than many detective operations in which the rod has placed no part; and it is easy to trace the possible or probable methods which he employed. If, for instance, during the period just preceding his engagement by the magistrates, he had, in coming to town from his residence, fourteen leagues distant, or in hanging about the town, where everybody was talking of the crime, picked up in any way the circumstances of the three fugitives entering

the house where the children were, it is almost inevitable that he would have obtained also some general description of their appearance, and I need scarcely remark, that the subsequent tracking of a hunchback would be no very difficult matter. It should be added here, that the judges who sentenced the hunchback, explicitly declared that they attached no weight to the indications of the rod as direct evidence of his guilt, but condemned him wholly upon his own confession, confirmed by abundant circumstantial evidence.

But this achievement of the rod, attested as it was by official records and by the public confession and execution of the criminal, made a great sensation in France; and Aymar was called to Paris, where both the court and the savans interested themselves greatly in his mysterious powers. Many marvellous feats are reported of him there; but the shrewd and rigorous experiments of the Prince de Condé exposed the emptiness of his pretentions. It was Aymar's claim that his rod was sensitive to the particular object which he was at the time seeking. When he sought a given murderer the track of some other murderer would not divert it. When he was pursuing a criminal he could not be led astray by subterranean water or treasure. If he felt these things in passing, his feeling was nevertheless distinguishable from that connected with his intention, etc. He could, at will, seek any given object, and when doing so could not be deceived. Unfortunately for this claim the tests of the Prince deceived him very often. For instance, a purse of money was shown him, and after he had got his "impression" of it, it was taken out to be buried in the garden, but instead of burying it, the person who had it kept it in his pocket. Aymar proceeded to the garden, and, undisturbed by the immediate neighborhood of the money in the pocket of a bystander, located the spot where he said it was buried. In another case he detected the gold of the gilding of a chair which was covered so as to permit a glimpse of its ornaments, but he sat on a similar chair, and walked through a saloon containing many of them, all completely covered, without discovering any gold. In another case a window was designedly broken in a palace. Aymar was sent for to trace the thief, who, he was informed, had recently stolen some money from the palace. His rod promptly indicated the broken window as the road by which the thief had entered, and he proceeded to trace also the route of flight, although no such theft had ever occurred. But so long as these and similar failures were not made generally public, Aymar continued to enjoy much celebrity,

and no doubt it was enough to turn the head of a peasant to be the object of such attention. Growing more audacious, he undertook to reveal character with his rod, and on one occasion, having received a fee from a gentlemen of the court, with the request that he would discover whether the gentleman's sweetheart was true to him, he sent for the lady's servant, and demanded of him another fee as a condition of certifying her virtue. Scandals of this kind became so bad that the Prince de Condé publicly exposed Aymar, and he returned to his home. On his way, however, in passing through a village he took occasion to designate five or six of the most respectable houses as the abodes of wicked women, which made a great uproar. I wish I could say that nothing more was afterwards heard of him; but unfortunately it appears that, as late as 1703, this man was employed during the civil war to point out with his divining-rod Protestants for massacre, under the plea of punishment for crimes they had committed.

We find connected with the exploits of Jacques Aymer a new theoretical explanation of the divining-rod. Many persons of more or less scientific training, not doubting the honesty of the man and the genuineness of the sensations which he manifested, cross-questioned him on the subject, and thus accumulated a mass of supposed data for the formulation of the natural law underlying these phenomena. It was at this time that the Cartesian philosophy was dominant in France, and the "subtle matter," "corpuscles," "animal spirits," and "vortices," of Descartes, furnished convenient hypotheses to explain almost anything. The two doctors of Lyons first supplied such hypotheses to the case Aymar, but the subject was treated at still greater length by the abbé de Vallemont, in his treatise on the divining-rod entitled *Physique Occulte*, and published in 1693. In this work he declares that by insensible transpiration particles escape continually from our bodies, that such particles pursue a vertical direction, and strike the divining-rod, which is thus caused to move up and down, assuming a line parallel to the path of the corpuscles. The holder of the rod receives corpuscular effluvia from other human bodies, and various substances, and communicates them through his pores to the rod, thus producing also a movement of revolution. The difference of the skin in different people results in various degress of susceptibility to particular impressions, but Aymar was, according to the abbé, possessed of an epidermis which could receive all kinds of impressions without

confounding them. The abbé says that there is a difference of form among the corpuscular effluvia of springs, minerals, bodies of thieves those of assassins, those of naughty women, those of landmarks, etc.; in other words he recognizes the existence of aqueous matter, larcenous matter, murderous matter, etc., and the last named variety was the only one which produced upon Aymar very painful impressions. This was due, according to his scientific expounder, to the vehemence of remorse which pervades the corpuscles of an assassin. The fact asserted by Aymar that he had detected and followed the trail of a murderer twenty-five years after the murder, and the fact that in almost every instance he necessarily began his researches a day or two after the crime—to say nothing of the cases in which he determined the locality of the landmarks which had been missing for an immemorial period, forced the abbé to a wild hypothesis of the extraordinary levity of the corpuscles, by virtue of which they remained a long time suspended in the air in spite of rain, wind and even other corpuscles of later origin.

Father Lebrun, in a pamphlet on *The Illusions of Philosophers Concerning the Divining-rod*, printed at Paris in 1693, seriously refuted the system of Vallemont. This pamphlet was republished in the third volume of Lebrun's *Critical History of Superstitious Practices* (Paris, 1702).

But Father Lebrun and a large proportion of those who took part in the discussion rejected the scientific theory altogether, and attributed the facts to Satan. It was asserted that not only wicked people might obtain the divining power by a league with the devil, but that such an alliance might be made unconsciously, and that the power might be conferred upon an unwilling subject, as a means of ruin to his soul. Several cases are described at length, in which persons in whose hands the divining-rod pointed out springs, etc., had been by prayer and fasting and the help of their spiritual advisers, delivered from this dangerous gift. The authorities of the church favored this view, at least so far as any moral uses of the divining-rod were concerned. In 1701 the Inquisition of Rome condemned the divining-rod and all writings in support of it.

(To be concluded.)

ATOMIC WEIGHT OF CARBON.—C. Friedel (*Bulletin de la Société Chimique*, xli. 100) by burning diamond in oxygen found the atomic weight of carbon to be between 12,007 and 12,017, if the atomic weight of oxygen is assumed to be 16.—*Dingler's Journal*, April 9, 1884. C.

THE TERCENTENARY CELEBRATION OF THE UNIVERSITY OF EDINBURGH.*

TECHNICAL EDUCATION. THE MECHANIC ARTS ABROAD AND AT HOME.

BY COLEMAN SELLERS,
M. Inst., C. E., etc.; Professor of Mechanics in the Franklin Institute.

MR. PRESIDENT AND MEMBERS OF THE FRANKLIN INSTITUTE:

Our Secretary has advised me that I am expected to speak of my representation of this society at the tercentenary of the University of Edinburgh, to touch perhaps on technical education and say something of my impressions of the state of the mechanic arts in Europe as compared with the state of the same arts here. Any one of these subjects, might, without being exhausted, fill all the time I dare take in the programme of this evening, so my remarks on all of them must be of the most superficial nature. In regard to the University of Edinburgh —I found on my return home a paper which I will read to you:

UNIVERSITY OF EDINBURGH, *May*, 1884.

Sir:—We, the undersigned, in the name of the University of Edinburgh respectfully request that you will convey an expression of our cordial thanks to the FRANKLIN INSTITUTE, Philadelphia, for their courtesy and kindness in deputing you as their Delegate to attend the Tercentenary Festival of the University of Edinburgh, and for the congratulatory address which, by your hands, they honored the occasion.

Owing to the friendly co-operation of the FRANKLIN INSTITUTE, Philadelphia, and other celebrated societies, the Tercentenary Festival became the greatest Inter-Academical and International gathering of distinguished men that, perhaps, the world has hitherto seen. A grateful memory of that illustrious assemblage, and of those who composed it, will ever be cherished by the University of Edinburgh.

We have the honor to be, sir, your faithful servants,

JOHN INGLIS, *Chancellor.*
STAFFORD W. NORTHCOTE, *Rector.*
A. GRANT, *Principal.*

PROFESSOR SELLERS, etc.

With the exception of this letter, I have already reported to the Board of Managers of the Franklin Institute fully as to the performance of my duty of representing this Society at so important a celebration. It is perhaps not out of place now, however, to say that it was

* Abstract of remarks made at the stated meeting of the Institute. Nov. 19, 1884.

with feelings of sorrow that I took the place of Mr. Frederick Ransome, who had been appointed delegate, I being named as alternate. Domestic affliction was weighing upon Mr. Ransome and he could not undertake what would have been great pleasure to him under other circumstances.

I promised him that I would tell you that it gives him pleasure to attend to such matters for the Institute as are intrusted to him in London, and that he deeply regrets his inability to act as the representative of the Franklin Institute at the Edinburgh Tercentenary. I need scarcely say that I assured Mr. Ransome that we fully appreciated all that he has done for us.

You have all heard of the many notable persons who collected to do honor to a university, that has become celebrated during the three centuries of its life. The good people of Scotland living in the beautiful city of Edinburgh, spared no pains to render the stay of the delegates very pleasant. Agreeable as this attention was, it rather prevented any social intercourse among the visitors, and the only chance to see those who were present from many noted colleges and learned societies in all parts of the world, was at the dinners and entertainments prepared for that purpose. There, one could hear such men as Professors von Helmoltz, Virchow, and Elize, Count Ferdinand de Lesseps, Professor Pasteur, besides a host of notable men from the institutions of English speaking countries. The most imposing ceremony was the presentation of the delegates to the representatives of the University of Edinburgh. On some of the most noted the degree of LL. D. was conferred at the same time, and this presentation afforded the chance to connect each in person with the name he bore. At the banquet, Earl Rosebery told the story of the college when proposing the toast "the Lord Provost, Magistrates, and Town Council of Edinburgh." For it was their predecessors, three hundred years ago, who founded this college without the aid of king or noble. As the speaker remarked, it was well the king gave none of the help he had promised, as he had nothing to give. Had he bestowed aught on the University of Edinburgh, it would have been placed in the position of receiver of stolen goods, for the king could only have given by robbing others. It was the people of Edinburgh, who aided and supported the university, and to it flocked students from all parts of England and Scotland. Those came to it who could not enter the older colleges, for in it alone, among all, was there no sectarian qualifi-

cation needed for entrance. The poor student bearing his bag of oatmeal for his winter support passed the house of John Knox, on Cannongate and perhaps bought his cheap books at the shop of Allen Ramsey on High street. Now, as then, no question is asked of him who enters and pays his modest fees. Through the years he can study and when he has tarried as long as his purse will permit, he can go into the world and use the mind-food he has consumed. It is only when he asks for a degree that he is examined to see if he has earned it. Very many of those who have been educated in the University of Edinburgh and who in after years have made their mark in the world have gone to that life work without graduating, perhaps to be honored by complimentary degrees when distinction had been achieved without the aid of a diploma.

After the foundation of the University of London, which is, like that of Edinburgh, free from sectarian requirements, there was some falling off in the attendance at the University of Edinburgh, the English institution taking its share of students. This, however, did not long continue and the attendance in Edinburgh is now over 3,000, more than half being students in the very excellent schools of Medicine. New and commodious buildings are being added to the college and the chief industry in Scotland's ancient capitol at this day, seems to be education. The direction of education so far as the University of Edinburgh is concerned, is like that of the other great seats of learning in Great Britain. It is confined to what they call the humanities; teaching the natural sciences, as in our technological institutions, is not yet much advanced in Great Britain. It is true, that there is a chair of engineering at Edinburgh, but I think it is more in name than of any practical utility as a means of teaching. I mean there are not many students who seek to be educated in engineering at that school. This leads me to say a few words on

TECHNICAL EDUCATION.

Sir Lyon Playfair, at the annual dinner of the Institution of Civil Engineers in London, answering, with Earl Granville, the toast "The Chief Seats of Learning of the United Kingdom," said that he had visited most of the technical schools of Europe and America, and he complimented the schools of our country saying that he was bound to admit that he had seen none so well equipped as in the United States; his version being, that "the Americans had foreseen that pro-

tection could not continue long to exist in their country, so they had established technological schools to meet the consequent competition of free trade." He then mentioned the Guild School which is starting in London, near the South Kensington Museum, and briefly alluded to work that is being done in Manchester, Leeds and some of the other manufacturing towns.

I cannot say that I accept the interpretation given by Sir Lyon Playfair as to the reason of the foundation of the great scientific schools of America. They seem to me to be the outgrowth of protection, the outgrowth of the advance in the trades brought about by protection and made necessary by the extended system of public education that has so long obtained here. Compulsory education is now being introduced into Great Britain, and is yet uncertain as to the best method of feeding the waters of the springs of learning to the young spirit thirsting for the draught, and at the same time to force it judiciously on those who have an hereditary distaste for such mental nourishment. It is not well for me to say over much about what is being done in teaching the sciences to the masses in Great Britain, but in Manchester and elsewhere I have seen some well-fitted schools. I have seen rooms fitted with spinning machinery close to the drawing school. I have seen where the art of dyeing is taught under the name of chemistry, where weaving too is taught, and all this in a city where the chief industry is the use of the spindle and the loom. Now with all due deference to the earnest men who have instituted these schools I must say to them, if the sound of my voice through the reporters this evening is to reach over the three thousand miles of water that separates us, that it will in time be found that trades must not be taught in schools that are intended to educate the masses. I doubt if they can be so taught to advantage. Technical education to be of the greatest advantage to the people in proportion to the money expended in the education, must be in the direction of "instructing without constructing." In other words, it will be found that the hands and eyes must be trained in the underlying principles. The use of tools must be taught as a means of educating the hands, and the mind at the same time; but not in teaching or restricting the teaching to some of the few trades that use those tools in common; and I would restrict the teaching to the use of hand tools in the lower schools. Drawing is being taught in a very thorough manner in many of the schools in Great Britain, and many of those schools are directly attached

to factories and work shops. Much is said about a great town that has sprung up near to Chicago, which is wonderful as showing how a dreary waste of swamp land can be reclaimed and made the habitation of a large number of active workmen engaged in one trade. The counterpart of this can be seen on the beautiful banks of the Aire, in England. Here, Sir Titus Salt founded years ago at his factories, the town of Saltaire, with many streets full of good stone dwellings, with large and commodious buildings for schools and public entertainment, with good pavements on the streets, such pavements as would put to shame the streets of this city of Philadelphia. An ample library is at the service of all the operatives, and the drawing school is conducted on the best principles of training the hand and eye and teaching habits of close observation. It was a treat to visit this place and see the neatness that prevailed, and to feast the eye on the brilliant verdure of the beautiful Park that skirts the Aire, and to stand on the handsome stone bridge that spans the water close to the green fields and to see the three thousand operatives trooping back to work from their dinner, looking contented, well-dressed, and with faces indicative of a higher education than is to be seen in many of the English manufacturing towns. In France, Germany, and in fact all the European countries I visited, there is a vast amount being done in technical education, so much that it is becoming the general belief that the schools of Europe are now fitted to turn out full-fledged engineers. This is, I fear, a great mistake, and I think I can see plainly to what it is leading. I have seen a locomotive, for instance, that required for its construction a specification covering the leaves of a large folio book of many pages, telling the maker how each minute part is to be constructed, regardless of the facilities that the maker might have to construct economically on his own system of shop sizes. The cylinders seem to be the work of one scientific expert on cylinders; the valve motion the work of another, the boiler was the brain work of a third, perhaps; and the whole brought together into one machine—well, I confess I know not how, but looking like too much science and not enough practice. Engineers are born, not made. Mozart was a musician above all others before the science of acoustics was known or understood. Great engineers have achieved their greatness without the aid of schools, but we know not how much more easy they might have done so, and how much more they might have accomplished could they have had the advantages of systematic technical education. No

technical school can give experience and judgment; these come through work and close observation. The technical school must train the habits of thought in the right direction to avoid needless waste of energy, must teach how to work, not aim to take the place of skill and experience.

THE MECHANIC ARTS, ABROAD AND AT HOME.

In regard to the mechanic arts, in the direction that my own profession would prompt me to look, I can only say that the subject is too great to be more than touched on. Landing on a foreign shore, modes of transport for man and matter first claim attention. A few days in Liverpool, for instance, and a ramble among the great docks and store houses, gives food for much thought. First the *very good* smooth pavements enable the horses to draw heavier loads with less labor than with us, and just here the contrast with our own city is so painfully humiliating to us, that I dare not take the matter of pavements into thought this evening, for I would then have little else to talk about. Power cranes for handling goods either on the docks, in the warehouses, or on the road, are admirable in design, and are more numerous than with us. I cannot say that they are better, than can be obtained here, but the people have come to require them more generally. Passenger elevators or "lifts" as they are called in England, are slow and far from equaling what we consider needful.

It was from Liverpool that the first passenger train, drawn by a locomotive, made its way to Manchester in 1829, or thereabouts. The English locomotive does not look like anything that we have under the same name. They are to my taste very handsome machines, well built and neat in their freedom from extravagant ornamentation. The nature of the climate renders the need of protection to the men on the engine of less moment than with us, and the old "drivers" object to the more modern English locomotives, upon which small cabs are being now placed. The majority of English locomotives are inside connected, and have crank axles. They differ from the American locomotive in almost all essential points of construction. Plate or built up frames are universal; our bar frame not being used. The equalizing system universal with us is not attempted, or deemed advantageous. The whole system of cars, either for passengers or freight is different, and so far as the passenger service is concerned, is

not to be compared with our own in comfort. Their light "coaches" are less steady than our heavier cars. To me it was always a delight when on one or another road I found the Pullman service in use, and yet I have been alone in a fine "drawing-room" coach while the ordinary, small, stuffy first-class coaches were filled with the natives who prefer their exclusiveness, I presume. As the locomotive department is so different in its conduct and its out-put from our own, one naturally notices the difference, and it will be well perhaps to confine my remarks to this subject, or at least to make it more prominent than any other. In the first place the manufacturers of locomotives cannot establish types and make them for sale in quantities. Each road has its own type of engine, and the builder must have his contract and be supplied with specifications before he can begin to work. On the other hand, the great roads of England employ talent of a high order in their locomotive department, recognizing the importance of a well designed and interchangeable system of service and the influence of the Superintendent of Locomotives, extends over all parts of the road where mechanical skill is required. The engine and the track are so intimately connected that they need be treated as a whole. Familiar as I was with the difference between the American and the English locomotive before I went abroad, I naturally turned my attention to the more recent developments in engineering in that direction. There are many great corporations controlling lines of travel in England, and it would be invidious to comment on one more than on another, as so much good work is being done by all.

On the London and Great Western, however, there has been attempted so radical a change from former practice that I may well take the work of its Locomotive Superintendent, Mr. Francis W. Webb, as the "example" this evening. Mr. Webb has compounded his engines, and he has kindly furnished me with very good photographs of his new engines, some of which I will show you this evening by means of the lantern on the screen. On my second visit to Crewe, where are the chief shops of the London and North Western Railroad, I had the pleasure of riding on the "Dreadnaught," the last of the perhaps fifty compounded engines that Mr. Webb has built. It ran well, steadily, and was as readily handled as any ordinary locomotive of the old type. We made sixty miles an hour up the heavy grade out of Crewe, and came down the same incline at what was said to be seventy miles an hour. The Dreadnaught has two pairs of driving

wheels, the hind pair of wheels being on a straight axle and the cylinders connected with them being outside the frame, what we call outside connection. The cylinders are set well back on the engine and the valve motion is that known as the "Joy," which dispenses with eccentrics, gets its motion from the connecting rod and obtains the lap and lead from the cross-head. So far as I have now described the engine, it is as if it had but one pair of wheels, on one axle and a pair of cylinders to actuate that one pair of wheels. The forward drivers are placed on a crank axle, there being one crank only, in the middle of that axle, and to this is connected a rod from one single cylinder, placed immediately below the smoke-box; the front cylinder head being flush with the end of the smoke-box. This one cylinder operating the forward pair of drivers has an independent valve motion and drives the front wheels, without any reference to the hind ones, so far as rate of revolution is concerned. This one cylinder is much larger than the cylinders that actuate the hind pair of wheels; it is, we will say, thirty inches in diameter; is in fact so related in size to the pair of cylinders, that the steam that is exhausted from them, enters this one cylinder at, say, forty pounds pressure, while the boiler pressure that gives the steam to the first pair is 180 pounds. No steam can reach the large cylinder that has not passed through the two smaller ones. The reversing machinery of the two separate sets of engines are connected, so that reversing one reverses the other.

I have said that Mr. Webb has about fifty of these engines on his road. They are also being tried in France. The inventor claims for them, great economy over the old type of engines, of the best construction, and he is encouraged by his company to go on with the experiment. As yet they have not been tried here. I have seen the design of the system adapted to our construction of locomotive, that is to the bar frame engine. From this room I will say to Mr. Webb that what is now wanted to influence the introduction of the engines here is mainly some exact figures as to economy, not as compared to what other engines on his road have done, but the foot-pounds of work as measured on a dynamometer car (such as is used on the Pennsylvania road), per pound of coal consumed. I think Mr. Webb has already undertaken to furnish this information, and we wait its publication before accepting the invention as an improvement over our practice. Here he will meet with the prejudice against the crank axle. The crank made by Mr. Webb is not so objectionable as the old form of double crank

axle. He makes a well-hammered straight axle, and then by hydraulic power bends it into a simple crank with easy curves from the straight part. All the early locomotive service on the Grand Trunk Railroad, of Canada, was inside-connected, with cranked axles, and the fearful breakage of these in the severe winter weather of Canada soon compelled the abandonment of the system. It does not follow that severe cold makes the axles more brittle, but it makes the road-bed less elastic and the hammering of the engine over the unyielding track is more severe on such pieces of machinery. I would like to comment very favorably upon many good points in the mechanical construction of Mr. Webb's engines; on the mode of making the fire-door holes, flanging both sheets out on an angle and riveting by power around the door hole, and swinging the door inward towards the fire in place of opening it out. He also dispenses with the bottom fire-box ring or "mud ring," and carries the water space in under the grate with an ash hole, like the fire-door, in the bottom of the box, and also one draft-hole low down on the vertical front face of the box.

A too hasty ramble through the shops of the London and Great Western road at Crewe was instructive, and there I had the pleasure of seeing a restored Trevethick high-pressure engine bearing date 1808, found by Mr. Webb, in a junk shop in London, and saved by him from the hammer of the scrap buyer. This engine will perhaps soon rest in the South Kensington Museum, along with the old engine of James Watt and the Headley Locomotive, and the other samples of the skill or ingenuity of the early mechanics.

I am told that there is now a movement on foot to build a monument to the memory of Trevethick, and to found scholarships in his name. I deposit with the Secretary, this evening, pamphlets fully explaining this matter. I cannot say that we can indorse the claim of Trevethick's admirers that he was the first inventor of the modern high pressure steam engine, as we believe that our own citizen, Oliver Evans preceded him by many years. In those days the interchange of thought between the two countries was not very easy, and the most favorable light in which we can view Trevethick's claim is that he re-invented the high pressure engine of Evans without taking the idea from him. One of the most interesting studies in mechanical progress that is possible in England and on the continent of Europe, is in the direction of typical machines, the progress of invention being manifest from the oldest machines being still in use. This is instructive, but

does not accord with our ideas of progress. New machines that can do more and better work should drive the old crude contrivances into the scrap heap and into museums.

The museums are indeed rich in mechanical curiosities. In Edinburgh, Prof. Archer having charge of the Museum of Arts and Sciences, has a number of workmen in a shop equipped with good tools, making large sectional models of important machines. He had just finished a model of the Headley locomotive, and I now deposit in the Institute the printed description of this model as furnished by Prof. Archer. In Birmingham I was in the private workshop of James Watt. Mr. Geo. Tangye now lives in the Watt mansion, and keeps intact the place where the great mechanic spent the last working days of his life. The coals placed there by his own hands still rest in his little furnace, and his leather apron, the apron worn by James Watt, lies on his turning lathe.

In the transmission of power by means of belts, as compared to gearing, the practice in America has long been in advance of other countries. The wide first driving-belts, common in our mills, are not to be seen in England, but a change is now under way in that direction, and, as is often the case when a new system is pushed, ultra novelties are adopted. A system is now obtaining in England of using hemp ropes as first drivers. The fly-wheel of the engine is grooved, and from four to five ropes of about one and a half or two inches diameter each, are made to carry the power to the grooved driving pulleys on the line shaft. Five ropes running from one grooved pulley to another grooved pulley with no means of equalizing the strain on each cord of the system is not according to our ideas of good practice. One rope must do more work than the others and will give out the sooner. I incline to the belief that one rope even acts as a retardent to the others. They give each rope ten horse-power work to do, and say they work well; but they have had as yet too few years of use to test their durability. I have been told that the ropes last several years. Compare this life with that of a good double leather belt as first driver in use for thirty years and as good, almost, as new! This is no uncommon thing in our practice. We, in the design of machines, are inclined to make all we can out of the belt power, doing as little as possible with the gearing. It is no unusual thing abroad to see very heavy machines with trifling belt power. I have to show you, however, this evening some samples of very good belt made of links of leather, put together edgewise, like

flat-linked chains. This form of belting is coming into very general use in England and in the Health Exhibition I had a chance to see the electrical machines, driven by this form of belt, as compared to ordinary leather belt and the merit of the link belt was manifest in the smooth running and freedom from vibration or wave. The belt is strong and very flexible I have been told that its driving power is no greater than that of solid belts of the same weight, but at high speeds the adhesion is greater from the belt not being so apt to carry air between its surface and the pulley.

Many months spent in a new country is not sufficient to constitute any one an unerring critic of the engineering ability of the people, as the circumstances that govern the engineering thought, differ. We cannot use English facilities of handling our freight at the stations because the construction of our cars is not the same; and climatic considerations weigh with us. I lingered long in England, among the kind friends who were so willing to show me all they could of their methods and their work, and can say but little about those countries where the people, as some one says, "labor under the disadvantage of not speaking our language." The two great engineering societies of England, the Institution of Civil Engineers and the Institution of Mechanical Engineers accorded to your representative every opportunity to avail himself of what they could do in the way of showing the work and the men who have done the engineering work of that country. This was accorded as freely before he was elected a member of each, as after. To the many kind friends who made him feel at home in a foreign land, he sends his thanks. To you, who met many of the representatives from those countries at the time of the Centennial, he brings their messages of kindly greeting. Go where he would, even as far to the north as the railroads would take him in Sweden and Norway, he met those who remembered the kindness of Philadelphia in 1876, and who send to Philadelphians their best and warmest wishes.

TERRESTRIAL MAGNETISM AT PARIS.—The organization of regular magnetic observations at the Observatory of Pere St. Maur required the determination of the horizontal component in absolute measure. The method of Gauss was employed, under the direction of M. Massart, and from observations on 21 days, between Feb. 6 and June 27, inclusive, the mean value was found to be, in C. G. S. units, $H = 0{\cdot}19414 \pm 0{\cdot}00012$. — *Comptes Rendus*, Aug. 4, 1884. C.

STEAM BOILERS AS MAGAZINES OF EXPLOSIVE ENERGY.

By Prof. R. H. Thurston.

(Concluded from page 448.)

It should be noted that equations (A) and (B) give the quantity of energy available from unity of weight of the fluid, expanding from the initial temperature and pressure down to the temperature of steam of atmospheric pressure, in a non-condensing engine. The energy produced by that part of the operation represented by the expansion-line, in the boiler explosion, is obtained by deducting from this total the product of initial pressure, above the atmosphere, by the initial volume. Table I, of "available energy," represents the total; Table II, that of "stored" energy, the latter part. The former is the measure of the maximum work possible in a non-conducting cylinder; it represents a limit which may be approached, but which can never be reached in practice.

The energy of steam alone, as stored in the boiler, is given by column 10 of Table II.* It has been seen that it forms but a small and unimportant fraction of the total stored energy of the boiler. Table III exhibits the effect of this portion of the total energy, if considered as acting alone.

The study of this table is exceedingly interesting, if made with comparison of the figures already given, and with the facts stated above. It is seen that the heights of projection, by the action of steam alone, under the most favorable circumstances, are not only small, insignificant indeed, in comparison with the height due the total stored energy of the boiler, but are entirely too small to account for the terrific results of explosions frequently taking place. The figures of Table III are those for the stored energy of steam in the working boiler; they may be doubled, or even trebled, for cases of low water; they still remain, however, comparatively insignificant. While they may account for the explosion effects seen at the Sandy Hook experiment, it is by no means certain to the mind of the writer that they do so;

* The figures here given should be substituted for those in Table II, which were uncorrected as above. The other columns remain practically unchanged.

it is very evident that they are not sufficient to account for the more violent explosions described. Either the energy stored in the water has been, in such cases, thus effective, or other sources of energy must be sought. These calculations, therefore, may, on the whole, be taken as strong evidence, if not absolute proof, of the correctness of the Colburn Theory of Steam Boiler Explosions.

TABLE III.—*Stored Energy in the Steam Space of Boilers.**

Type.	Energy total.	Stored in steam. Per pound of boiler.	Height of projection.	Initial velocity.
1 Plain cylinder	676,698	271 ft. lbs.	271	132
2 Cornish	709,310	42 "	42	52
3 Two-flue cylinder	2,377,351	351 "	351	150
4 Plain tubular	1,622,731	168 "	83	83
5 Locomotive	1,483,896	76 "	76	69
6 "	2,135,802	85 "	85	74
7 "	1,706,447	86 "	86	74
8 "	1,302,431	107 "	107	83
9 Scotch marine	1,462,430	54 "	54	59
10 " "	2,816,392	61 "	61	62
11 Flue and return tube	1,570,517	28 "	28	42
12 " "	1,643,854	29 "	29	43
13 Water tube	2,103,110	61 "	61	59
14 " "	3,513,830	79 "	79	71
15 " "	1,311,577	24 "	24	39

* Table III and related text were not ready at the time of printing the preceding part, and did not therefore appear in copies then distributed.

INFRA-RED RAYS AND BANDS.—H. Becquerel was led, by his examination of incandescent metallic vapors, to apply his methods to the solar spectrum. He publishes a table of wave lengths for the infra-red lines and bands, ranging between 760 and 1,880 millionths of a millimetre. His results show that the phosphorographic method, when the phosphorescent substances are suitably chosen, enables us to explore the lower regions of the spectrum as completely as the thermoscopic methods, and more thoroughly than chemical actions. The method has the advantage of giving instantaneous indications, and of presenting an image of the whole region which is explored.—*Comptes Rendus*, Sept. 1, 1884. C.

SOME PRINCIPLES AND RESULTS OF HARMONIC MOTION.*

By Pliny Earle Chase, LL.D.

"When two bodies, in relative motion, come into contact, pressure begins to act between them to prevent any parts of them from jointly occupying the same space. . . . Any force in a constant direction acting in any circumstances, for any time great or small, may be reckoned on the same principle; so that what we may call its whole amount during any time, or its '*time-integral*,' will measure, or be measured by, the whole momentum which it generates in the time in question." (Thomson and Tait, *Nat. Phil.*, i, sec. 294, 297.)

No relative motions can be more important, and no contact more complete, than those which exist between the all-pervading luminiferous æther and the sun. In the conversion of tangential luminous waves into spherical vibrations, gravity is acting in a constant direction toward the sun's centre. The amount of its activity upon each æthereal particle, μ, or its time-integral during each cyclical period, t, is measured by μgt. The study of the various correlations which flow from this integral involves the following considerations:

1. The principle of Galileo, that the total effort is equivalent to the effective sum of the causes which are operating. This is illustrated at sun's surface, which is the region of greatest energy in our system, by the cyclic equation, $\Sigma g = gt = v_\lambda$.

2. The equality of pressures or resistances to opposing forces, in all equilibrating tendencies. In consequence of this equality, every interruption or prevention of the free action of any force may be measured as a rate of change of momentum in the opposite sense.

3. The invariability of the sum of kinetic and potential energies.

4. The maximum of kinetic energy in all cyclical motions, at the point of the trajectory which is nearest to the centre of force, and the maximum of potential energy at the point which is most remote from

---

*This paper has been written, in part, to meet a desire which has been expressed by some members of the Royal Astronomical Society for an introduction to the article on "Harmonic Motion in Stellar Systems" (this Journal, Nov., 1884). The author will feel under obligation to any readers of the Journal who will inform him of other points which need further elucidation.

that centre. At the origin of luminous radiation, where $\Sigma g = v_\lambda$, the reaction of gravitating resistance is all kinetic; after a half rotation it becomes all potential, but it is then combined with a new reaction which is all kinetic.

5. The evidences of local æthereal stress, which is operative in various forms of gravitating, thermal, electro-magnetic and chemical attraction and repulsion.

6. The indestructibility of energy, which requires, as Maxwell has stated, that energy must exist in the æther during the interval of its transfer from one body to another.

7. The strong reasons for believing that the media for luminous, gravitating, thermal, electro-magnetic and chemical interactions, occupying the same space and represented by the same cyclical velocities, are identical.

8. The counteraction of stress by obvious elasticity, as in a spring, or by probable intermolecular elasticity and orbital motion, as in the resistance of solids.

9. The principle of Fourier, that any complex periodic motion must be compounded of a definite number of simple harmonic motions, of definite periods, definite amplitudes and definite phases.

10. The application of "Laplace's coefficients," or spherical harmonic analysis, to the explanation of cyclical waves and vibrations in spherical elastic masses.

11. Cumulative and progressive undulating tendencies, resulting in complex harmonic motions of various kinds.

The evidences and consequences of harmonic motion in stellar systems flow simply and naturally from the two following important FACTS:

1. The fundamental velocity in the solar system is the velocity of light.

2. This is not a merely accidental and temporary coincidence, but according to the first proposition of "Newton's Principia," it must have existed and must continue to exist, during all past and future stages of solar condensation.

The first of these facts was discovered by investigating the tendencies to oscillatory nodal harmony in elastic media. It appears to be still regarded, by some persons, as merely curious and without important significance. This is, perhaps, because attention has been so often directed to the angular velocities in different orbits, which vary

inversely as the $\frac{3}{2}$ power of the mean distance, that the synchronous variability of angular velocity with the inverse square of the radius, in all the particles of an expanding or contracting nebular nucleus, is forgotten or overlooked.

We find in our stellar system three stages of material aggregation: 1. A nucleus, probably consisting chiefly if not entirely of condensed gas, rotating in about 25·5 days. 2. An atmosphere of lighter gas, rotating synchronously with the nucleus and, therefore, extending no further than Kant's limit ($\rho_a = 36{\cdot}35\rho_o$; ρ_o being Sun's semi-diameter). 3. A luminiferous æther which, if infinitely elastic, may be of infinite extent, but which would reach if made homogeneous to 2210·74 times Earth's mean distance from the Sun.

If the Sun were homogeneous and unresisting, a particle would fall to its centre, from its surface or from any point within its surface, in 41·87 minutes, or in $\frac{1}{4}$ of the time of free revolution at the surface ($\frac{1}{4}$ of $2\pi\sqrt{\frac{r}{g}} = \frac{\pi}{2}\sqrt{\frac{r}{g}}$.) The relation of radial oscillation to orbital revolution is, therefore, that of simple harmonic motion. The velocity acquired by falling from the surface to the centre would be $\sqrt{gr}$, which is the same as would be acquired in falling from an infinite distance to $2r$, or from $2r$ to r, or in virtual fall through $\frac{1}{2}r$, or through one-half the length of a cycloidal pendulum which would oscillate synchronously with circular orbital revolution at r. It is also the velocity of wave propagation in a homogeneous elastic atmosphere of a depth equivalent to r.

At all points within the nucleus, the velocity acquired by fall to the centre would be proportional to the distance from the centre. Let us apply the principles which are here indicated to a stellar system like our own, with a nucleus so preponderating that its oscillatory tendencies are not materially modified by the perturbations of attendant planets or companion stars.

Within our solar nucleus all the tendencies to orbital revolution have been converted into constrained rotation, which shows a retardation by collision, subsidence-oscillations, etc., such that the velocity of every particle is only about $\frac{1}{210}$ as great as that of free and self-sustained revolution. The continual violent agitation of Sun's mass indicates the probability of synchronous radial and tangential oscillations, which are dependent upon simple harmonic motions. The measure of

gravitating acceleration for the oscillatory unit of time being $\pi^2 l = \frac{3\pi^2 l_\circ}{2}$, ($l_\circ$ being the distance from the point of suspension to the centre of oscillation in a linear pendulum l), we have Sun's semi-diameter $(\rho_\circ) = \frac{3\pi^2}{2} l_\circ$ and the quotient of circular orbital velocity by equatorial velocity of rotation $(\sqrt{g_\circ \rho_\circ} \div v_r) = \left(\frac{3\pi^2}{2}\right)^2 = 219{\cdot}17$.

The principle of conservation of areas requires that the angular velocity should vary inversely as the square of radius, without the nucleus as well as within it, provided we look merely at the orbit of any given mass or particle. It is only when we compare different extra-nucleal orbits in the same system, each of which has its own original force of projection, that we find angular velocities varying inversely as the $\frac{3}{2}$ power of the mean distance. If the nucleus is expanding or contracting, the Kantian radius, ρ_κ, should, accordingly, vary as the $\frac{4}{3}$ power of the nucleal radius, so that $\rho_\kappa = \left(\frac{3\pi^2}{2}\right)^{\frac{4}{3}} \rho_\circ = 36{\cdot}35\rho_\circ$.

The free undulatory velocity at $\rho_\circ$, both radially and tangentially, is $\sqrt{g_\circ r_\circ}$. The mean harmonic radial velocity of rotary oscillation at the same point is $\frac{1}{\pi}$ of $\left(\frac{2}{3\pi^2}\right)^2 = \frac{1}{688{\cdot}54}$ as great, or $\left(\frac{1}{688{\cdot}54}\right)^2$ as great as the fundamental velocity, or the gravitating acceleration in the fundamental oscillatory unit of time.

As the idea of "fundamental velocity" will be new to many readers, it may be well to explain it. In whatever way g may act, whether by constant, successive, or undulatory, pressures, thrusts, or pulls, all of its results may be accounted for on the hypothesis of successive instantaneous impulses. The entire accelerating force, gt, is always exerted, but a portion is usually counteracted by opposing resistances or momenta. Suppose, for example, three bodies in a vacuum; A falling freely for a second, B suspended from a string between cycloidal arcs so that its centre of oscillation is $\frac{1}{\pi^2}$ of 32·08 feet from the point of suspension, C sliding on a frictionless plane in which $h : l :: 1 : \pi^2$. A will fall 16·04 feet, while B swings once and C slides 16·04 feet, falling through a height equivalent to one-half the length of the pendulum.

The choice of a second as the unit of time is altogether arbitrary. The desirability of a natural unit has often been felt and expressed. Maxwell suggested, as a suitable unit, the interval of some particular luminous wave-length. At the surface of a stellar nucleus, where gravity is a maximum, where the time of rotary oscillation can be linked with all possible times of revolution by simple formulas of harmonic vibration, and where a universal gravitating unit can be readily framed from the units of mass and density, the velocity, gt, which is indicated both by the gravitating and by the æthereal unit,* may properly be regarded as a fundamental velocity.

It is at present impossible to test the oscillatory velocities in remote stellar systems, but as the considerations on which they are based are universal, there are good grounds for believing that their influence is equally universal, so that $gt = v_\lambda$ at every stellar surface. In the solar system we find $t^s = 1101227$ sec. = oscillatory unit of time = one-half solar rotation.

$g_\rho = \pi^2\rho_\rho = \pi^2\left(\frac{3\pi^2}{2}\right)^{\frac{4}{3}}\rho_\circ$ = unit of gravitating acceleration in unit of time at ρ_ρ.

$g_\circ = \pi^2\left(\frac{3\pi^2}{2}\right)^{4}\rho_\circ$ = unit of gravitating acceleration at $\rho_\circ$ in oscillatory unit of time = v_λ in oscillatory unit of time = solar modulus of light (= 185505 miles per sec.) = 185505×1101227 miles = $(688{\cdot}54)^2\rho_\circ$.

$g_\circ \div \pi\left(\frac{3\pi^2}{2}\right)^{\frac{1}{2}} = \sqrt{g_\circ\rho_\circ} = v_\circ$ = radial velocity acquired by falling from $\rho_\circ$ to the centre of a homogeneous nebular sphere = self-sustained velocity at surface of the sphere (= 269·42 miles per sec. at Sun's surface) = $269{\cdot}42 \times 1101227$ miles in t_ρ.

$\sqrt{g_\circ\rho_\circ} \div \frac{\pi}{2}\left(\frac{3\pi^2}{2}\right)^{\frac{1}{2}} = v_\rho$ = simple harmonic radial component of stellar equatorial velocity of rotation (= ·7826 miles per sec. for our Sun) = $2\rho_\circ \div \pi$ in t_ρ.

The cumulative influence of mean luminous undulation and solar action is shown by the proportions

$$v_\rho : v_\circ :: v_\circ : \tfrac{1}{2}v_\lambda.$$
$$v_\rho : v_\pi :: v_\pi : v_\lambda$$

* The time of virtual fall through one-half homogeneous æthereal atmosphere.

In the second of these proportions v_π is parabolic velocity, or velocity acquired by infinite fall, at Sun's surface.

In studying planetary harmonies, regard should be paid to the following cyclical tendencies:

$t_1 \propto (d)^{\frac{1}{2}}$ in simple oscillation under a constant force.

$t_2 \propto d$ in cyclical motions which are immediately determined by luminous undulation, or by other constant velocities.

$t_3 \propto d^{\frac{3}{2}}$ in different orbits, under different original forces of projection but with the same central force.

$t_4 \propto d^2$ in a rotating and uniformly expanding or contracting nucleus.

If d in each instance is equivalent to the Kantian limit (ρ_π) and if the mean density of the rotating mass is represented by δ,

$$t_1 \propto \left(\frac{1}{\delta}\right)^{\frac{1}{2}} \qquad t_2 \propto \left(\frac{1}{\delta}\right)^{\frac{1}{2}}$$

$$t_3 \propto \left(\frac{1}{\delta}\right)^{\frac{1}{2}} \qquad t_4 \propto \left(\frac{1}{\delta}\right)^{\frac{3}{2}}$$

If the mean density of Earth's Kantian rotation is taken as the unit, the corresponding reciprocals of density for Sun and for the several planets, except Neptune, are nearly as follows:

Sun	649·800	Mars	1·053
Mercury	1·207	Jupiter	·171
Venus	1·031	Saturn	·182
Earth	1·000	Uranus	·157

The influence of luminous undulation upon the actions and reactions between the chief centre of nucleation and the chief centre of condensation (Sun and Earth), seems to be indicated by the following tendencies:

t_2, in the conversion of circular motion into simple harmonic motion, $\propto \frac{2}{\pi} d$. d_3 representing such conversion, $\propto \left(\frac{2}{\pi}\right)^{\frac{3}{2}} d$.

The radius of mean condensation ($\frac{1}{2}\delta$) is $2^{\frac{1}{3}}$ times the radius of actual condensation; $365{\cdot}256 \times \left(\frac{2}{\pi}\right)^{\frac{3}{2}} \div 2^{\frac{1}{3}} = 214{\cdot}54$. The apparent solar semidiameter which corresponds to this value is 961·43″, which differs by less than $\frac{1}{213}$ of 1 per cent. from the British Nautical Alma-

nac estimate, 961·82″. Dr. Fuhg's estimate (*Astron. Nach.*, 2040), 961·495″, is still closer.

Tendencies to solar equatorial acceleration and polar retardation, such as are shown by the sun-spots, are indicated by the following approximations to the period of solar rotation:

$t_1 \propto \sqrt{d}$; $(36{\cdot}3514 \times 430891) \div (6{\cdot}6 \times 3962{\cdot}8) = (24{\cdot}472)^2$.

$t_2 \propto d$; $430891 \div (3962{\cdot}8 \times 3{\cdot}92295) = 27{\cdot}7174$.

$t_3 \propto \sqrt{\delta}$; $(36{\cdot}3514 \div 6{\cdot}6)^2 \times 3{\cdot}92295 = (25{\cdot}602)^2$.

$t_4 \propto d^2$; $(36{\cdot}3514 \div 6{\cdot}6)^2 = 30{\cdot}336$.

The secular influence of the chief centres of nucleation and nebulosity (Sun and Jupiter) on the chief centre of condensation (Earth), as well as the cyclical actions and reactions between Earth and Jupiter, are shown by the equation $\delta_\beta \rho_{3\beta} \div \delta_\odot \rho_{3a} = t_\beta \div t_a$.

In this equation δ_β, $\delta_\odot$, are the mean Kantian densities of Jupiter, Sun; $\rho_{3\beta}$, ρ_{3a}, the nearest secular approaches of Earth to Jupiter, Sun; t_β, orbital period of Jupiter; t_a, Kantian or rotational period of Earth. The secular eccentricity of Earth which satisfies this equation is ·06543. Stockwell's estimate is ·06774.

FLASHING TESTS FOR GUNPOWDER.—Prof. Chas. E. Munroe, U.S.N.A., cites descriptions of flashing tests, as follows: *Ordnance Instructions*, U.S.N., p. 345; Capt. Smith, R. A., in his *Hand-Book of the Manufacture and Proof of Gunpowder*, p. 83; Commander J. D. Marvin, in his *Objects and Resources of the Naval Experimental Battery*, p. 18; Col. Chabrier, in *Comptes Rendus*, lxxviii, 1138, and *Revue d' Artillerie*, iv, p. 396. Since the flashing test is the simplest, readiest, and in the hands of an expert, the best test for the incorporation of powder, and since it also fairly indicates the amount of deterioration which a powder has undergone during transportation and storage, it seemed desirable to seek some method by which the record could be made permanent. He believes that he has secured such a permanent record, by employing the paper which is used in the "Blue Print Process" of photography, and is easily procured in commerce. He prefers that which is issued by the Pennsylvania Railroad Company, for use among its operatives. His communication describes the various tests, and concludes with a satisfactory statement from Lieut. Commander W. M. Folger, U.S.N., commanding the Naval Experimental Battery.—*Jour. Amer. Chem. Soc.*, vol. 6, Jan. 1884. C.

ELEMENTARY PHYLLOTAXY.

By Pliny Earle Chase, LL.D.

I have shown* that the "numerics" of the chemical elements can be better represented by various phyllotactic divisors, than by Prout's law. Phyllotactic submultiples of the organic elements, C, H, O, N, give a mean residual ratio of ·05654, while Prout's law gives ·12007, the probable ratio of merely accidental residual being ·18394. This indicates comparative aggregate probabilities which are represented by the reciprocals of $\cdot05654^{65}$, $\cdot12007^{65}$, and $\cdot18394^{65}$, or by 1999×10^{20}, 1098×10^{9} and 1.

In the *Philosophical Magazine* for November, 1884, Dr. Edmund J. Mills gives additional evidences of phyllotactic influence. He represents all the elementary numerics, except that of hydrogen, by the equation,

$$y = p15 - 15(\cdot9375)^{x}.$$

This introduces the first five numbers of the phyllotactic series, 1, 2, 3, 5, 8, the equation being of the form

$$5 \times 3\,[p - (\overline{5 \times 3} \div \overline{2 \times 8})^{x}].$$

The sum of the infinite series which is represented by $15\,(\times\overline{5\times3}\div\overline{2\times8})^{x}$ is the product of the first five phyllotactic numbers, $1 \times 2 \times 3 \times 5 \times 8$. The fundamental ratio is of the form $(n \div \overline{n+1})$, thus representing cumulative harmonic rupturing tendencies of the same kind as are shown in the inter-stellar æthereal influence upon planetary positions. (*Jour. Frank. Inst.*, Nov., 1884, p. 349.)

An Error by Maxwell.—In his article on "Ether," in the Encyclopædia Britannica, Maxwell makes an inadvertent numerical transposition, giving 842·8, instead of 482·8, for the coefficient of rigidity, and deducing a consequent erroneous value for æther-density, $9{\cdot}36 \times 10^{-19}$, instead of $5{\cdot}36 \times 10^{-19}$. The error has been copied into some valuable text-books.—P. E. C.

Alpine Electromotors.—It is proposed to utilize the enormous water power of the Alps as a motive force for many of the electric railways in Switzerland. The first application of this kind will probably be from Saint-Moritz to Pontresina, a distance of about 9 kilometres.—*Lumiere Electr.*, May 31, 1884. C.

---

* *Proc. Amer. Phil. Soc.*, xix, 591–601, xx, 431, etc.

GLIMPSES OF THE INTERNATIONAL ELECTRICAL EXHIBITION.

By Professor Edwin J. Houston.

No. 4.—Dolbear's Telephonic Researches.

As we have already intimated, Professor A. E. Dolbear, besides inventing the new system of electro-static telephony, has done much to give the present system of magneto-electric telephony its present commercial efficiency. His inventions in this direction cover a wide and varied field of research. We will describe some of the more interesting and valuable of these inventions.

It would appear that Dolbear was the inventor of the magneto-electric telephone. He was the first to point out the fact that the ordinary electro-magnets employed in the articulating telephone could be dispensed with, and permanent magnets used in their stead. He invented the magneto-electric telephone in September, 1876, and constructed his first magneto-electric telephone as early as October of the same year.

Fig. 1.—Dolbear's Original Magneto-Electric Telephone.

In Fig. 1 is shown the original Dolbear magneto-electric telephone from a photograph of the identical apparatus. As will be seen, it was somewhat crude in construction but was fairly efficient in operation and contained all the essentials of the magneto-electric instrument.

A permanent bar magnet *A*, had a coil of insulated wire *C*, wound around one end only. Its armature was formed of a rectangular piece of sheet-iron fastened to the middle of a thin rubber diaphragm, that was firmly stretched on the end of one of the hard-rubber tubes of an old opera glass. This form of apparatus was designed for use both as a transmitter and as a receiver, and was employed without a voltaic battery.

Crude as this instrument was, its invention marked a great advance

in the art of telephony. Like many things that appear of the greatest simplicity when once originated, its successful operation could hardly have been confidently predicted. Indeed, we doubt whether most electricians would have believed that the magneto-electric currents thus generated by the voice would possess the requisite strength to reproduce the voice. It would scarcely have been considered probable that the resulting magnetic variations in the receiving instrument could produce such movements in the diaphragm as would permit it to reproduce audible, articulate speech. The scientific world was then, to a great extent, ignorant of the exceedingly small amount of motion requisite to produce audible sounds. It also lost sight of the very evident fact, that the comparatively great velocity of movement of the magnetic diaphragm, must necessarily result in the production of a proportionally large current in the coils of wire on the magnet pole.

FIG. 2.—Dolbear's Magneto-Electric Telephone (Bi-polar).

Dolbear improved the magneto-electric telephone shown in Fig. 1, by an instrument that he constructed in December, 1876. This form of instrument is shown in Fig. 2, and consists of a horseshoe magnet of round steel, that is, of course, permanently magnetized. Bobbins of insulated wire are placed on the ends of the poles in the position shown. Fig. 2 is reproduced from a photograph of the instrument as actually made by Prof. Dolbear. It is interesting as showing a metallic diaphragm, bolted at its edges to the upright, wooden mouth-piece. The bobbins on this instrument were taken from an old telegraphic instrument. Dolbear employed his first metallic diaphragm in October, 1876, in an instrument used in connection with the apparatus shown in Fig. 1. His first metallic diaphragm consisted of a piece of sheet-iron that entirely covered the end of a wooden tube.

In Fig. 3 is shown an ingenious form of transmitter invented by Dolbear in 1878, and named by him the finger transmitter. It consists

of an empty tomato-can, the metallic bottom of which is brought into good electrical contact with one end of an electric circuit by wrapping the wire around the bottom edge and soldering it thereto. If now the wire from the other terminal of the battery circuit be grasped in the hand, and the finger be held against the middle of the bottom of the can, as shown, any sound made into the open end of the can will vibrate its bottom and thus vary the strength of the battery circuit, by reason of the varying contact of the finger and the bottom of the can. If, therefore, any form of receiving instrument be introduced into the circuit, anything spoken into the open end will be distinctly heard in the receiving instrument.

FIG. 3.—Dolbear's Finger Transmitter.

Since the resistance of the finger is high, it is necessary to employ from ten to twenty gravity cells in order to obtain satisfactory results.

This form of transmitter is dependent for its operation on the principle of the microphone transmitter, or in other words, it is a variable resistance transmitter. Though of comparatively little practical importance, it is interesting as illustrating the ease with which efficient telephone transmitters may be constructed; or how readily one could be devised for use in case of a sudden emergency.

In a previous article we spoke of Dolbear employing for a transmitting instrument a modified form of Reis transmitter. In Fig. 4, is shown a back view of one of these modified transmitters. A brass tongue, the end of which is tipped with a platinum wire is fastened to the inside of a wooden ring, so that the end of the platinum tip touches the middle of a vibrating diaphragm. The screw that may be seen passing through the cross bar, serves to regulate the pressure of the

platinum tip upon the plate. The brass tongue has one of the terminals of a battery connected with it, and the metallic plate or diaphragm is connected with the other terminal. These wires are shown in the figure as passing through the handle.

Fig. 4.—Dolbear's Modified Reis Transmitter.

This transmitter, which, it will be observed differs from the forms employed by Reis, mainly in the fact that the ordinary membraneous diaphragm is replaced by a metallic diaphragm, has been successfully employed by Prof. Dolbear to transmit intelligible, articulate speech between Boston and New York. When used for this purpose it was included in the circuit of 100 gravity battery cells, and the speech reproduced by the receiving instrument was so loud and distinct, that it was heard at a distance of ten feet from the receiver.

This transmitter is especially effective when included in the primary circuit of an induction coil. Without stopping here to discuss the peculiar advantages of the induction coil in telephony, it may be well to remark that the currents sent over the main line from the secondary coil are of the alternating character that characterize the magneto-electric currents.

Besides the modified Reis transmitter shown in connection with Fig. 4, Prof. Dolbear has invented a number of multiple transmitters; one of these is shown in Fig. 5.

In this form of transmitter four separate terminals are shown, so arranged that all of them may be placed in the same circuit, or each may have a separate circuit of its own, and thus be employed with one induction coil, like a single terminal one, "or with multiple points, each with its own circuit in an induction coil with multiple primaries, or with separate coils, or any combinations of these." In this form of transmitting instrument, Dolbear has arranged the vibrating plate horizontally as in Reis's second form of transmitter.

Dolbear has invented a quite distinct genus of telephone receivers

to which he has given the general name of rotophones. This instrument, like Edison's motograph, operates by variations in friction. It is quite distinct, however, in the method of its operation, an electric current being caused to modify the magnetic friction of a body attached to the centre of an elastic diaphragm.

FIG. 5.—Dolbear's Multiple Transmitter.

In Edison's motograph, a diaphragm is set into vibration by the variations in the friction of a metal strip on a cylinder of chalk. The chalk cylinder is saturated with an electrolyzable substance and is rotated. The passage of an electric current between the metal and the chalk will cause the friction between these two surfaces to become less. If, therefore, the cylinder be rotated the friction will vary with variations in the current, and corresponding movements will be produced in a diaphragm that is connected with the metallic strip.

FIG. 6.—Dolbear's Rotophone.

Now Prof. Dolbear employing these variations in magnetic friction has constructed a distinct genus of receiving telephone, the principles of operation of which will be understood by reference to

Fig. 6. An electro-magnet, with a straight core, is provided with a handle so that the core can be readily rotated. A flat U-shaped armature is provided, the ends of which are permitted to rest on the ends of the core that project beyond the coil. In the middle of the U-shaped armature a short rod is secured at one end, the other end of which is attached to the centre of a vibrating plate of mica, or elastic metal. The explanation of its action is thus stated by Prof. Dolbear in a paper descriptive of the rotophone, that he read before the American Academy, on May 14, 1879. "When a current of electricity is made to traverse the coil, the core becomes a magnet and the armature is attracted to it; if the core be rotated, the adhesion of the armature will carry the middle of the diaphragm towards the magnet, and if the current be stopped, the elasticity of the plate will cause it to return to its original place. A vibrating current will thus set up corresponding vibrations in the diaphragm so long as the magnet turns."

Prof. Dolbear has produced some very simple and curious modifications of this form of telephone receiver. For example, if the end of the string of a common string telephone be tied to a nail, and the latter be placed on the pole of an electro-magnet that is in the circuit of a transmitting instrument, a person listening at the tube of the string telephone, will distinctly hear whatever is uttered into the transmitter, provided the nail is slowly drawn over the magnet pole. A motion of but two inches a minute will be sufficient in most cases.

Fig. 7.—Early Forms of Dolbear's Static Telephones.

In Fig. 7, two of the early forms of Dolbear's static telephones are shown. One of these consists of two tin discs about two inches in diameter, separated from each other by a rubber ring about a quarter of an inch in breadth, thus forming a true air condenser. These were mounted in wooden cases, with an opening through the face for listening.

The form of static telephone shown in Fig. 7, to the right, consists of a circular plate of tin securely fastened to the bottom of a shallow box. Electric conduction, between the back and front disc is prevented by the use of a ring of paraffined paper. The front disc was formed of a disc of gilt paper, tightly stretched over a ring and connected to one of the terminals of an induction coil.

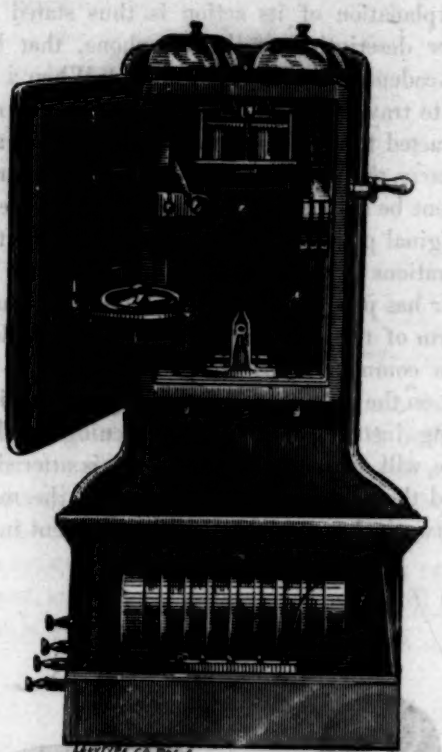

FIG. 8.—Dolbear's Secondary Ringers.

The two forms above described in connection with Fig. 7, were but a few of the numerous evident modifications of the same that were tried. Dolbear also made a telephone receiver, of a series of condensing discs. In one instance as many as fifty of these separate discs were used. As might have been expected, however, this modification was not productive of any good results.

The resistance of Dolbear's receivers is of course very great. One of them, he states, has a resistance of upwards of 10,000 megohms, while its capacity is about 2 or 3 ten-thousandths of a microfarad.

In Fig. 8 is shown Dolbear's arrangements for call bell, transmitter, etc. The handle, shown near the upper right corner of the figure, when turned rapidly makes and breaks the circuit of a number of battery cells that are placed in the lower part of the box. In this circuit is included the primary wire of an induction coil seen in the lower part of the figure. The ends of the secondary coil are connected to the main line, and the currents produced therein by induction, consequent on the making and breaking of the primary circuit, traverse the main circuit and ring the bell at the distant end of the line. By means of this exceedingly efficient form of apparatus, call bells are readily rung at distances of over 1,000 miles.

The ends of the secondary coil being connected with the main line the electrical charges are of course sent into the plates of the receiving instrument that is placed in a branch circuit between the terminals of the induction coil.

The ringing of the bell, therefore, at the same time charges the receiving instrument and thereby sensitizies it to its maximum, thus fitting it to act as a delicate receiver when removed from its hook.

The transmitting instrument is attached to the door of the box and is then enclosed when the door is shut. It consists of a shallow box with a modified Reis transmitter in which the platinum points ordinarily employed by Reis are replaced by carbon tips.

CENTRAL HIGH SCHOOL,
PHILADELPHIA, November 25, 1884.

PRIVATE TELEPHONE.—John Burns, a Glasgow merchant, has united his office with his house, a distance of fifty-two kilometres, or over thirty miles, by a telephonic wire. In order to prevent disturbance from the induction of neighboring wires, he uses a return wire, the two wires being so arranged as to resemble the two threads of a twisted cord. Imagine, upon each arm-post, four positions at the four right angles of a square. The sending wire is attached to insulator 1 on the first post, 2 on the second, 3 on the third, 4 on the fourth, 1 on the fifth, and so on, forming a very elongated helix. The return wire is attached to insulator 4 on the first post (at the angle opposite to 1), 3 on the second, 1 on the third, 2 on the fourth, 4 on the fifth, etc., forming a helix parallel to that of the sending wire. In this way the effects of induction are neutralized in the two wires. The electric insulation is so perfect that neither the passage of trains nor telegraphic despatches in neighboring parallel wires produce any disturbance. —*Chron. Industr.*, May 25, 1884. C.

THE UTILIZATION OF NATURAL GAS.*

To the President and Members of the Engineers' Society of Western Pennsylvania:

GENTLEMEN.—Your committee appointed in January to examine into and report upon the utilization of natural gas, beg leave respectfully to submit the following report:

After prompt organization we have held a number of meetings, and have visited several prominent manufacturing establishments where natural gas is being used. We have examined into the methods of distributing and regulating the pressure in mains, and the question of municipal control.

We have from the outset taken counsel with the Board of Insurance Underwriters of Allegheny County.

We have to express our grateful acknowledgments to the following gentlemen for courtesy in affording us facilities for the prosecution of our work: President Ford, of the Pittsburg Plate Glass Works, Creighton Station, Pa.; Messrs. Atwood & McCaffrey, Messrs. Carnegie Bros. & Co., Mr. Howard Morton, Forward Avenue, East Liberty; Mr. Pew, of the Penn Fuel Company; Messrs. Spang, Chalfant & Co., Fuel Gas Co., all of Pittsburg.

It is now nearly twenty-five years since the first wells drilled into the sand and rocks of Venango County gave origin to the great and steadily increasing petroleum industry, but we have only recently begun to realize that with the petroleum is associated an invisible fuel, which by reason of its calorific power and the variety of its possible applications may yet assume a degree of commercial importance comparable to that of petroleum.

I. Natural gas from Western Pennsylvania is, in most cases, a mixture of more or less complex character. The few investigations published during the past few years tend to show that it is essentially composed of the hydro-carbons of the series known in chemistry as paraffins. In an accompanying table are enumerated some of the leading members of this series.

---

* Report of a Committee of the Engineers' Society of Western Pennsylvania, presented May 21, 1884.

Table showing the properties of the chief gaseous elements of natural gas and including some of the heavier hydro-carbons.

Paraffins.	Condition.	Composition.		Specific Gravity of vapor.	Heat units yielded by 1 lb. in burning.	Cubic feet of air theoretically needed to burn 1 cubic foot of vapor.
		Per Cent. Hydrogen	Per Cent. Carbon.			
Marsh Gas.....	Gas.....	25·04	74·96	0·5576	13·370	9·56
Ethane.....	Gas.....	20·05	79·95	1·043	12·469	16·74
Propane.....	Gas.....	18·22	81·78	1·522	12·145	23·92
Butane.....	Gas, liquefies at 34° Fahr.....	17·28	82·72	2·007	Not yet experimentally determined for the higher members.	31·10
Pentane.....	Liquid, boils at 100° Fahr.....	16·71	83·29	2·49		38·28
Hexane.....	Liquid, boils at 158° Fahr.....	16·32	83·68	2·97		45·45
Heptane.....	Liquid, boils at 210° Fahr.....	16·04	83·96	3·46		52·63
Octane.....	Liquid, boils at 255° Fahr.....	15·83	84·17	3·94		59·80

From the table it is evident that the members differ in their relative proportions of carbon and hydrogen. The vapors of these hydrocarbons are heavier as the proportion of carbon is greater. The calorific values show the superiority of marsh gas, weight for weight, over all the others. The first three are odorless; among the others the odor is stronger in proportion as the amount of carbon is greater. A remarkable similarity of chemical properties is exhibited by all, and by reason of the strong attraction existing between them, the boiling point of a mixture is always found to be considerably higher than that of its most volatile constituent. They are theoretically the point of departure for the formation of a great number of useful compounds, such as alcohol, chloroform, acetic acid, and glycerine, but, on account of serious technical difficulties, due chiefly to their remarkable resistance to ordinary chemical reagents, (paraffin, parum and affinis), they have never yet been turned to practical account. They are not actively poisonous. It should be stated that many of these paraffins are known to exist in several different modifications, differing especially in boiling points. Hence the list of boiling points above given must be understood as merely including the temperatures at which the typical members of the paraffin series pass from the liquid to the vapor state. It will serve to show that what is a gas or vapor in summer may become a liquid in winter,

Table of Analyses of Natural Gas. (*From Various Sources.*)

Constituents.	1 Petrolia, Canada.	2 West Bloomfield, N. Y.	3 Olean, N. Y.	4 Fredonia, N. Y.	5 Pioneer Run, Venango Co., Pa.	6 Burns' Well, near St. Joe., Butler Co., Pa.	7 Harvey Well, Butler Co., Pa.	8 Cherry Tree, Indiana Co., Pa.	9 Leechburg.	10 Creighton.	11 Penn Fuel Co.'s Well, Murraysville.	12 Fuel Gas Co.'s Well, Murraysville.	13 Roger's Gulch, Wirt Co., W. Va.	14 Gas from Marsh Ground.	15 Baku, on the Caspian Sea.	16 Gas occluded in Wigan Cannel Coal.	17 Blower in Coal Mine, Wales.
Hydrogen	Chiefly marsh gas with ethane and some carbonic acid.	.....	.....	A mixture of marsh gas, ethane and butane.	Chiefly propane with small quantities of carbonic acid and nitrogen.	6·10	13·50	22·50	4·79	Trace of heavy hydro-carbons.	Marsh gas with a little carbonic acid.	19·56	Chiefly marsh gas with small quantities of nitrogen and 15·86 per cent. carbonic acid.	.....	0·98	.....	.....
Marsh Gas		82·41	96·50			75·44	80·11	60·27	89·65	96·34		78·24		47·37	93·09	80·69	95·42
Ethane		.....	.....			18·12	5·72	6·80	4·39	.....		.....		.....	.....	4·75	.....
Propane		.....	.....			trace	.....	.....	trace	.....		.....		.....	.....	.....	.....
Carbonic Acid		10·11	.....			0·34	0·66	2·28	0·35	3·64		.....		3·10	2·18	6·44	0·60
Carbonic Oxide		.....	0·50			trace	trace	trace	0·28			.....		.....	.....	.....	.....
Nitrogen		4·31	.....			.....	.....	7·32	.....			.....		49·39	0·49	8·12	3·98
Oxygen		0·23	2·00			.....	.....	0·83	.....			2·20		0·17	.....	.....	.....
"Illuminating Hydro-carbons"		2·94	1·00			.....	.....	.....	0·56			.....		.....	3·26	.....	.....
		100·00	100·00			100·00	99·99	100·00	100·00			100·00		100·03	100·00	100·00	100·00
Specific gravity		0·693	0·692			0·6148	0·5119		0·5589	0·5923	0·56						

1. Fouqué, "Comptes Rendus," lxvii, p. 1045.
2. H. Wurtz, "Am. Jour. Arts & Sci." (2) xlix, p. 330.
3. Robert Young.
4. Fouqué, "Comptes Rendus," lxvii, p. 1045.
5. " " " " "
6. S. P. Sadtler, Report L, 2d Geol. Sur. Pa., p. 153.
7. S. P. Sadtler, Report L, 3d Geol. Sur. Pa., p. 152.
8. S. P. Sadtler, Report L, 3d Geol. Sur. Pa., p. 153.
9. S. P Sadtler, Report L, 3d Geol. Sur. Pa., p. 153.
10. F. C. Phillips.
11. Robert Young.
12. Rogers.
13. Fouqué, "Comptes Rendus," lxvii, p. 1045.
14. Bischof's "Chemical Geology," I. p. 730.
15. Bischof's "Chemical Geology," I, p. 730.
16. J. W. Thomas, London "Chem. Society's Journal," 1876, p. 793.
17. Same, 1875, p. 793.

In the lower sand rocks of the oil regions occur probably all the members of the series, the less volatile flowing as petroleum, and the more volatile existing in a state of compression ready to escape through every opening.

Natural gas is then a mixture of the most volatile of these hydro-carbons, carrying various quantities of the vapor of the less volatile compounds. The lightest member, marsh gas, (so called from its constant occurrence among the products of vegetable decay), is the chief element of the gas likely to be supplied to Pittsburgh. In addition to these, hydrogen, carbonic acid, carbonic oxide, oxygen, and nitrogen are found.

It is stated that $C_2 H_4$, ethelyne, and other hydro-carbons of the series known as olefines occur, but positive evidence upon this point is wanting, except in the extreme north end of the oil field. An accompanying table gives a general view of the composition of gas from a number of wells.

The table illustrates the predominence of marsh gas. Natural gas is usually a little more than one-half as heavy as air. The gas from Sheffield, Warren county, has a specific gravity of 0·45, while that from Pioneer Run, if the analysis of Fouqué is correct, must be about 1·5.

As the gas and oil sands all have a slight dip towards the southwest the gas in the southern part of the region is drawn from rock strata which are higher in the geological series than those yielding the gas in Northern Pennsylvania and New York State. If any attempt at a generalization may be made with the few data at disposal, it appears, therefore, that the deeper strata yield in general a gas of higher specific gravity and illuminating power.

Analytical data covering a greater area of gas-producing territory may in the future throw important light upon the interesting question of the origin of gas and oil. The theory which traces both to the sea-weeds of the ancient Devonian sea, which once covered Western Pennsylvania, has been very generally popular. Exhalations of combustible gas have been frequently met with in other countries, although nowhere in quantity comparable with the prodigious out-flow from the gas wells of Western Pennsylvania.

In the district Tsien-Luon-Tsing, in China, gas is obtained in large quantity from salt-well borings, and is used in boiling down the brine, and also for illuminating and heating purposes. ("*Comptes Rendus*,

vol. XII, page 667). Some of these borings are 3,000 feet deep, and penetrate carboniferous strata, yielding gas under great pressure. Many openings have been made with the special view to utilizing the gas.

The escape of gas bubbles, which readily take fire and burn, is a common occurrence in strongly saline mineral springs. In the salt mines at Slatina, in Hungary, natural gas escaping from fissures has been utilized for illuminating the mines. This is an unusual instance in which the active component of the terrible enemy of the mines—fire-damp—has been made into a useful servant. Considerable volumes of combustible gas frequently issue from fissures in the well-known "mud-lumps," which form at the mouth of the Mississippi.

II. Wells drilled for natural gas, outside of the oil regions, are of recent date, with a few exceptions. The wells at New Cumberland, W. Va., have supplied gas for more than twenty years for the manufacture of bricks. The East Liverpool wells have been burning twenty-five years, and are still productive. At Beaver Falls, natural gas has been used for six years in a cutlery works, but lately the gas has failed, presumably on account of the wells becoming filled up with either paraffin wax in the pores of the rock, or with an incrustation of salts of lime and magnesia, as it is said they have never been cleaned out since they were drilled. At Erie so many wells have been drilled to the strata of gas rock that it has become partially exhausted. In the oil regions, a gas well was looked on rather as a curse than a blessing, and, as most of the wells produce gas as well as oil, and so many were drilled to the same sand or rock, it soon exhausted the supply.

Our city has the advantage of being able to tap three or four prolific gas belts or fields: The Butler County field, which supplies Spang, Chalfant & Co.; the Bull Creek, or Tarentum field, which struck gas at 1,147 feet depth, and supplies the Pittsburgh Plate Glass Company, Pennsylvania Salt Manufacturing Company, and will supply Richards & Hartly's and Chalinor & Taylor's new glass houses, and Godfrey & Clark's new paper mill. The Murraysville, or Turtle Creek and Lyon's Run field, which tapped the gas at 1,337 feet depth, and supplies the gas for the Acme Gas Company, used by the Edgar Thompson Steel Works; the Fuel Gas Company, which furnish the gas to the several mills and glass houses on the South Side; the Penn Fuel Company, which furnish the Union Iron Mills, Park Brother & Co. Limited, Wilson, Walker & Co., Hussey, Howe & Co., Shoenburger

& Co., and many other works in the same neighborhood on the Allegheny river. The belt or field in Washington County, in which the celebrated McGuigan well is found, the gas from which is being piped to the South Side. No doubt other prolific fields will be found to produce gas in the near future.

We have records of depths of different wells in different districts which we thought best not to include in this report.

If small wells are struck on the same belt as large ones, and are not sufficiently productive to be utilized, they should be plugged, as they drain the belt to no purpose. The more durable wells tap the gas-producing strata generally at a greater depth than one thousand feet.

It is a common opinion among those versed in the management of gas wells that the outflow is subject to a gradual diminution, tending ultimately to total extinction. Evidence of this is to be found in all parts of the gas territory, where gas wells have been long in use. In many localities, however, there is reason to think that the gradual falling off of the supply of a well, is due to the choking up of the pipe by a deposit of salt or paraffin, rather than to the failure of the original source. This is notably the case with the Freeport gas wells.

The following historical facts in regard to the wells drilled by Spang, Chalfant & Co., are of interest in this connection:

No. 1. Has been in use nine years, and is still a good well.

No. 2. Four years in use, still blowing, though with diminished force. Its location is three miles distant from any other gas belt.

No. 3. Yield insignificant.

No. 4. Pressure diminished from 1½ pounds to 0 in one week.

No. 5. Failed after four years' use.

No. 6. In use six years; gradually failing.

No. 7. Failed after five years' use.

No. 8. Good yet; drilled in 1883.

No. 9. Dry hole on Anderson farm; struck quick-sand at depth of over 1,100 feet.

No. 10. Was a small well.

No. 11. A good well; gas struck within the past few days.

These wells being all in Butler County, their partial failure may be due to close contiguity to the numerous oil wells of that district by which they have been drained.

These wells have been supplying the mills of Spang, Chalfant & Co. some years with varying success, being able to supply the entire plant

at times, and then as the wells failed, and before others could be drilled, the gas supply was sometimes insufficient, and it was therefore either necessary to stop part of the machinery, or return to the use of coal.

III. The number of companies chartered to supply natural gas in Pennsylvania up to February 5, 1884, was 150, representing a capital stock of $2,160,580. Since that date, a large number of new charters have been granted.

IV. Natural gas next to hydrogen, is the most powerful of the gaseous fuels, and if properly applied, one of the most economical, as very nearly its theoretical heating power can be utilized in evaporating water.

It is used for almost all the purposes to which coal is applied, with one notable exception, viz.: for smelting ores in blast furnaces, and it is our belief that at no distant day it will be used for this, but not in the present style of furnace.

Being so free from all deleterious elements, notably sulphur, it makes better iron, steel and glass than coal fuel. It makes steam more regularly (as there is no opening of doors, and no blank spaces are left on the grate bars to let cold air in), and when properly arranged, regulates the steam pressure, leaving the man in charge nothing to do but to look after the water, and even that could be accomplished if one cared to trust to such a volatile water tender. Boilers will last longer, and there will be fewer explosions from unequal expansion and contraction, due to cold draughts of air being let in on hot plates.

Gas engines of large size can be built to be driven by natural gas, as in the case of the Otto, and other styles.

Table showing comparative effects of different gas fuels.

	Heat Units yielded by 1 Cubic Foot.	Number of Cubic Feet Needed to Evaporate 100 Pounds Water at 212 deg. F.
Hydrogen	183·1	293
Water Gas (from coke)	153·1	351
Blast Furnace Gas	51·8	1038
Carbonic Oxide	178·3	313
Marsh Gas	571·0	93·8

For domestic purposes a beautiful fire can be made, dust, ashes and

coal carriage avoided; smoke, and the smoked ceilings and walls of Pittsburgh may become things of the past, yet if sold at prices now charged, *i. e.*, 50 cents per thousand cubic feet, it is much more costly than coal, especially if used in grates and stoves constructed for coal. The invention of burners for its more economical consumption in stoves must follow its general introduction.

As the introduction of natural gas has been of such recent date in this city, most of its users consume it in such a crude manner that they fail to get its best results, the difficulty being the expense of making the necessary changes in the burning. There is, however, one notable exception among the large consumers, namely the Union Iron Mills of Messrs Carnegie Bros. & Co., where it is being used with economy in Siemens' regenerative furnaces.

An experiment was made to ascertain the value of gas as a fuel in comparison with coal in generating steam, using a tubular boiler of 42 inches diameter, 10 feet long, with 4-inch tubes. It was first fired with selected Youghiogheny coal, broken to about 4-inch cubes, and the furnace was charged in a manner to obtain the best results possible with the stack which was attached to the boiler. Nine pounds of water evaporated to the pound of coal consumed was the best result obtained. The water was measured by two metres, one on the suction, the other on the discharge. The water was fed into a heater at a temperature of from 60° to 62°. The heater was placed in the flue leading from the boiler to the stack in both gas and coal experiments. In making the calculations the standard 76-pound bushel of the Pittsburgh district was used; 684 pounds of water were evaporated per bushel, which was 60·90 per cent. of the theoretical value of the coal. When gas was burned under the same boiler, but with a different furnace, and taking a pound of gas to be 23·5 cubic feet, the amount of water evaporated was found to be 20·31 pounds, or 83·40 of the theoretical heat units were utilized. The steam was under the atmospheric pressure, there being a large enough opening to prevent any back pressure: the combustion of both gas and coal was not hurried. It was found that the lower row of tubes could be plugged and the same amount of water could be evaporated with the coal, but with gas by closing all the tubes (on end next to stack) except enough to get rid of the products of combustion when the pressure on walls of furnace was three ounces and the fire forced to its best it was found that very nearly the same results could be obtained. Hence it was

concluded that the most of the work was done on the shell of the boiler. Another experiment was made with the tubes plugged entirely, and a very small opening leading to stack and with an increased pressure on the furnace and of course a different style of burner; the results were nearly the same but the rivets and seams began to suffer, although only the same amount of gas was burned, but not in the same time. The gas required much more air to accomplish complete combustion per pound of fuel than coal. One singular fact was noticed, that is, when the products of combustion showed the smallest amount of carbonic oxide, the best results were not obtained. This was probably due to the fact that the increased heat due to the burning of the carbonic oxide to carbonic acid did not compensate for the loss occasioned by the amount of air that had to be let in to burn it and which air had to be heated to about 1500°. As the air, gas, and water were all accurately measured, the results were considered very nearly correct. Analysis of the gas in the escaping products of combustion were made quite often, only carbonic oxide and carbonic acid being determined.

Natural gas is being extensively used in heating boilers; in most cases by introducing a gas pipe with a row of small holes on its side, the fire space being closed up partly to check excessive draught.

No other data as to evaporative power are at the disposal of the committee, but it is apparent that in none of the boilers seen by us is the method of heating to be regarded as economical. A portion of gas taken from the flue of a 42″ × 24′ two-flue boiler consuming natural gas was found to contain nitrogen, 85·88, carbonic acid 6·16, and oxygen 7·96, showing that a great excess of air was passing up the chimney, notwithstanding that in this instance more than usual care was taken in the regulation of the draught.

So long as metres are not employed in measuring the volume of gas consumed in manufacturing establishments, it is scarcely probable that owners will study economy in its use. But with an increased demand for natural gas, particularly when its superior heating qualities, and low price, as compared with coal are understood, the officials of the supplying companies will doubtless take such action as will prevent the reckless waste of this valuable natural product. If, for instance, as it might be shown by cheap contrivances, easily applied, a factory could be better supplied with only one-third the present consumption of gas, the owners would certainly deem it no hardship if a meter was

placed at their establishment, provided rates were not increased. In fact it is most probable that a perfect system of supply will reach many more consumers and with rates much lower than have heretofore been charged. At present the want of method by the companies, forbids as rapid a development of the gas supply as the public wants really require. Heretofore it seems that contracts have been made to supply the gas at rates only a trifle less than the cost of coal, but in the haste to declare dividends the companies seem to forget that by permitting its reckless waste by a few large consumers, they are crippling a resource which would yield better financial results through a more general distribution at more reasonable rates.

ILLUMINATING POWER.

V. The composition of the gas now being brought to Pittsburgh renders it improbable that it will compete with coal gas as an illuminant, until some specially suitable form of burner has been contrived. Pure marsh gas yields about one-half the light produced by coal gas.

Experiments made with a view to charging natural gas with the vapor of heavy hydrocarbons, have been thus far unsuccessful, the mixture tending to separate in the gas holder into layers of different composition.

USES.

VI. It has been attempted to apply natural gas to the conversion of iron into steel.

Experiments having in view the dephosphorization of iron through the agency of the hydrogen of natural gas have been made, but thus far the results have been very unsatisfactory. Imperfectly burned at a high temperature the gas deposits carbon in a form having a remarkable density. Upon this principle the manufacture of electric light carbons is now becoming an extensive industry in the hands of the McTighe Electric Light Company.

The tendency of the gas when under pressure is to absorb and carry off oil and grease, and leads to its being used for the cleansing of delicate fabrics.

The powerful reducing action of the gas upon metallic oxides at high temperatures may lead to its application to the smelting of metals upon a large scale.

The application of gas to glass making, on account of the purity of the fuel, has led to the production of superior glass; more rapid fusion is posible, and covered pots are found unnecessary.

VII. Pipes of various sizes and strengths have been tried and with different kinds of sockets or couplings. Standard weight wrought iron pipes, with fine and coarse threads, tapering threads and sockets, light pipe with the Converse joint, (which is a cast-iron socket caulked with lead, the same as ordinary cast-iron water pipe).

Lead rings have been used between the beveled ends of the pipe, in the regular socket. Pipes have been screwed together with fine threads, and the sockets caulked with copper wire. Cast-iron gas pipe with caulked lead joints has been used at Wellsburg, West Virginia, but on account of the high pressure of the gas, proved a failure, the gas leaking not only through the joints, but through the pores of the iron in many places.

The tapering socket, with pipe cut to match, seems to have the best record.

If standard wrought-iron pipe be used and laid in ditches below the frost line and care be taken in laying, no allowance need be made for expansion, for the flow of gas will keep the pipes at a fairly even temperature of not much over 45° Fahr., and no trouble from expansion or contraction need be feared. This statement, of course, does not apply to lines laid in cinder banks or where they are exposed to extreme changes in temperature due to proximity to furnaces, etc.

Light oil-well casing should not be used for pipe lines, because first, it is only ·1885 inches thick at its thickest part, and the thread (14 to the inch) reduces it ·061 inch leaving therefore, only ·1165 inch thickness, which is not sufficient. Again, some soils, and more especially cinder banks will rapidly corrode such thin pipes.

The Acme Gas Company use a $\frac{1}{8}$-inch pipe of somewhat less than the standard weight, but still heavy enough to resist all ordinary pressure and strains.

The Fuel Gas Company have two lines of $5\frac{5}{8}$ light casing, but they will never repeat this mistake, as they are about to lay two lines of standard weight pipes; all their city connections are made with standard weight pipes.

The Penn Fuel Company laid one line of $5\frac{5}{8}$ *casing*, and one line of 8-inch *pipe*. Connections to mills are made with standard pipes, but it is to be regretted that this company laid any casing inside the city limits.

The varying requirements of a large iron works will render it desirable to be able at all times to control an unlimited volume of gas supported by high pressure.

In private dwellings the danger from explosions due to leaks in the pipes would be enormously increased by a pressure much exceeding that of ordinary coal gas in the service mains. In the opinion of the committee a pressure of over 6″ water pressure should be forbidden by law in pipes leading to dwellings.

Table showing comparative inflammability of natural gas and coal gas.

Mixture of Natural Gas and Air.		Effects.	Mixture of Allegheny City Coal Gas and Air.		Effects.
Gas.	Air.		Gas.	Air.	
1 volume.	4 volumes.	Burns feebly.	1 volume.	4 volumes.	Burns feebly.
1 "	6 "	Burns slowly.	1 "	6 "	*Explodes.*
1 "	7 "	Burns slowly.	1 "	7 "	Burns explosively.
1 "	8 "	Burns rapidly.	1 "	8 "	" "
1 "	9 "	Burns explosively.	1 "	9 "	" "
1 "	10 "	*Explodes.*	1 "	10 "	Burns explosively—less rapid.
1 "	12 "	Burns somewhat explosively.	1 "	12 "	Flashes.
1 "	13½ "	Burns quietly.	1 "	13¼ "	No flash.
1 "	15 "	Flashes, but flame dies out.	1 "	15 "	"
1 "	16 "	Very feeble flash.	1 "	16 "	"

The importance of having the high pressure mains, as they enter the city suburbs, subjected to careful tests, and the mode of laying such pipes under municipal control, cannot be over estimated.

We are convinced that most scrupulous care is being bestowed, both by prominent manufacturers, in the construction of pipes and valves, and by some of the gas companies, in the selection of material.

The necessity for a reduction of the pressure, which is often 75 or 100 pounds per square inch as the gas comes from the well, to an amount not exceeding 5 inches water pressure in the street mains, renders the selection of regulating valves for accomplishing this purpose of great importance. The regulators proposed are of two classes.

1. *Valves.*—Among the best known is the Luther valve, by which it is proposed to reduce the high pressure in the mains leading from the well to an amount suited to the purpose to which the gas is to be applied, and to preserve constantly this lower pressure.

From what the committee have seen in the use of valves, we believe we are justified in the statement that not one has yet been suggested which will satisfactorily answer the purpose.

2. *Tank Governor.*—This is undoubtedly the best form of regulator which the committee has seen tested. It is similar in principle to the gasometers or holders employed at all the large gas works.

EXPLOSIBILITY.

VIII. The fact that natural gas if mixed with air will explode on contact with fire, and is in effect the dreaded fire damp of the coal mines is no argument against its introduction and general use under due precautions.

To those who understand its character, it is wholly unnecessary to state that the qualities which render it explosive when mixed with excess of air are the very ones which render it valuable as a producer of light and heat.

Taking the gas from Creighton Station, Western Pennsylvania, as approximately representing in composition the gas now being used in the city, the following trials were made with a view to ascertaining the limits of its inflammability.

Different mixtures of measured quantities of natural gas and air were prepared, and also mixtures in the same proportions of coal gas and air. The effect was noted when a coal gas flame was plunged into each. From these results we concluded that in a room filled with air containing $\frac{1}{10}$th to $\frac{1}{12}$th gas the danger would be one of explosion; above or below these limits, there would be danger of fire, but not of explosion.

A natural gas charged with the higher members of the series of paraffins (see Table page 49) would flash or explode when diluted with a still larger proportion of air. On the other hand if the air in a room contains $\frac{1}{6}$th or $\frac{1}{7}$th coal gas, contact with flame would cause explosion, while with an admixture of $\frac{1}{10}$th or $\frac{1}{11}$th of coal gas, there would be danger of fire, but not of explosion; as will be seen as regards safety there is a difference in favor of coal gas.

As coal gas is richer in free hydrogen, the most easily inflammable

of all gases, its temperature of ignition may be assumed to be somewhat lower. The well-known property of coal gas, of rendering a mass of spongy Pt. or Pd. incandescent, is found to be generally wanting in natural gas.

Accurate experiments (*Bulletin de la Société Chimique*, 1883, page 2, Mallard & LeChatelier) have shown that a mixture of O. and H. ignites at 552°C. while a mixture of Marsh gas and O. ignites at a temperature between 600° and 660°C. A calculation shows that a cubic foot of natural gas mixed with 9·2 cubic feet of air, and fired, will produce an expansion to 91 feet. A cubic foot of coal gas mixed with 6½ cubic feet of air will, on explosion expand to 73·3 cubic feet. It has been found that a flash travels in an explosive mixture of natural gas and air at a rate considerably exceeding 18′ per second in a 2″ pipe.

Natural gas brings with it from the well the minute quantities of heavier liquid or solid hydrocarbons which are carried along in the form of vapor or spray by the force and velocity of the gas under high pressure, and impart to it a strong and characteristic smell.

A peculiar substance resembling butter is often taken from the mains bringing the Murraysville gas to the city. A specimen of this substance was found to contain common salt, water, small quantities of lime and magnesia salts, coarse sand and a considerable quantity of solid paraffin all blown into a kind of light froth.

The odor of the gas in the mains appears to be dependent upon these traces of condensible hydrocarbons, for if kept in a closed vessel for a few days, the gas becomes absolutely odorless. The odor will therefore in all probability diminish more and more as it is carried away from the wells, or from the high pressure mains. This may explain the contradictory statements upon this point which have found circulation.

It has been found that air containing 10 per cent. of Murraysville gas (fresh from the high pressure mains) has a decided odor; this is also true of Freeport and Creighton gas, but the same gas after standing in an air-tight glass for 24 hours had lost every trace of odor. Owing to their minute quantities and rapid condensation, these heavier hydrocarbons are not easily accounted for in an analysis.

Air containing 2 per cent. of Allegheny City coal gas has been found to possess a decided odor.

IX. The velocity of the gas depends largely on the amount of fric-

tion it has to overcome, as well as the initial pressure it has in coming from the well. A well which with its conducting pipes indicated pressure of 3¼ ounces of water at the mouth took just 4¼ minutes for the gas to traverse the 16,000 feet of pipe, which was then connected on, the pressure running up to 15 pounds at the well, due to the increased resistance in the friction of the pipe. The following experiment was also made. Gas was turned into the pipe with an initial pressure of 90 pounds per square inch. It took just 2¼ minutes for it to traverse the 16,000 feet of pipe.

Natural gas pipes should be laid without any right angled elbows, or other fittings of the kind; changed direction in the line should be made by bending the pipes, and no bend should have a radius of less than 48 inches for a 6-inch pipe, or eight times the diameter of the pipe.

Gas from a well having a pressure of 20 ounces had a velocity of 23,400 feet per minute; a rubber ball was driven through three miles of a 5⅛ casing pipe in 2½ minutes.

When gas is blowing freely from the mouth of a well, the pressure has not been found in any case to reach 2 pounds per square inch.

Statements in regard to higher pressures than this are probably in error.

The gas as it issues from the wells has a temperature of 42° to 45° Fahr.

At the moment of release from the well the volume no doubt undergoes a very considerable expansion, resulting in a lowering of the temperature.

This absorption of heat due to expansion may perhaps explain the fact that blocks of ice are often seen to be thrown from the stand pipes while the gas is burning with a powerful flame.

The temperature has been found to be 45° in several of the mains in Pittsburgh.

X. At the time of the appointment of this committee, the prominent legal question of interest to natural gas companies was the definition of their rights to lay their pipes in the city streets, and as corrollary to this, the responsibility resulting from explosions or other accidents due to the use or presence of the gas. But recently a more important question has been brought forward by the decision of the local court that but one natural gas company under the law of 1874, is authorized to supply gas to consumers in this city.

As the law of 1874 is so frequently referred to in the newspapers, it may be useful to introduce it here for the benefit of readers who may not have ready access to a law library.

LAWS OF PENNSYLVANIA.

Act approved 29th of April, 1874, relating to water, gas, light and heat companies.

*1. Companies incorporated under the provisions of this statute for the supply of water to the public, or for the manufacture and supply of gas, or the supply of light or heat to the public by any other means, shall, unless otherwise provided by this act, from the date of the letters patent creating the same, have the powers and be governed, managed and controlled as follows:

Clause 1. *Gas, heat, light—powers of companies.*

2. Where any such company shall be incorporated as a gas company, or company for the supply of heat and light to the public, it shall have authority to supply with gas light the borough, town, city or district where it may be located, and such persons, partnerships and corporations residing therein, or adjacent thereto, as may desire the same at such price as may be agreed upon, and also to make, erect and maintain therein the necessary buildings, machinery and apparatus for manufacturing gas, heat or light from coal or other material and distributing the same with the right to enter upon any public street, lane, alley, or highway, for the purpose of laying down pipes, altering, inspecting and repairing the same, doing as little damage to said streets, lanes, alleys and highways.

3. And impairing the free use thereof as little as possible, and subject to such regulations as the councils of said borough, town, city or district may adopt in regard to grades, or for the protection and convenience of public travel over the same.

When the act of 1874 was passed, electric lighting was in its infancy, and it has been suggested that in deference to the promises of scientific men regarding its then future, that the terms of the act were purposely made so diffuse as to cover its possibilities—as instance, "The supply of gas, or the supply of light or heat to the public *by any other means.*"

This vagueness and want of supplementing legislation is a source of evil in various ways, and it is the opinion of the well-informed, that

---

* 1. Act 29th April, 1874, 34 P. L. 93.

2. Id.

3. In Bloomfield, etc. Gas Light Company vs. Calkins, 62 N. Y. 386.

1. Thomps & Co., 541; it was held that gas pipes could not be laid under country highways without compensating the owners of the fee. See supra, p. 56, N. 2, Dillon vs. Gas Light Co., 1 McArthur, 626.

as the knowledge of electric lighting and of natural gas is *now* better understood, there is an urgent demand for additional legislation.

There can be no doubt about the fact that the intention of the law-givers, was to encourage both the electrician and the gas man, but the wants of the two interests are so different that only confusion and trouble will attend their affairs, until their rights and privileges are separately, and distinctly defined, and this it is reasonable to believe could be much more effectually accomplished by new legislation, than by awaiting decisions based upon such fundamentally defective laws, as that of 1874.

Under the law as understood by this committee, natural gas companies have the right to lay their pipes in the streets of towns and cities, with precisely the same privileges as coal gas companies, so far as such rights extend. But this does not prevent cities from passing laws based upon "reasonable grounds" ordaining the mode of laying the pipes as far as the language of the act cited allows as regards grades or for the protection and convenience of public travel over the same.

In regard to the question of the right of the city to restrict the gas companies, as to pressure in, and size and strength of pipes, etc., a difference of opinion exists, but under the head of "police regulations" it is believed by the committee that any insufficiency of strength in the pipes, or defective workmanship in the joints which might cause explosions, a city can in its charter find grounds for interference, and protect itself by the enforcement of appropriate legislation. But from the extent to which even this apparently wise and proper proposition has been debated, it is made clear that further action is demanded by the legislature. It does not, of course, comport with the character of this paper, even if the committee felt able to do so, to attempt to criticise the recent decision of the court, which is generally construed to grant one company, to the exclusion of all others, the privilege of supplying the city of Pittsburgh with natural gas.

Natural gas had been used under the boilers of engines at wells in the northern oil fields before the passage of the act of 1874, and to some extent it had been introduced into dwellings for domestic consumption, but it was then considered a waste product, which any one could dispose of by sale or gift, as could be done with any natural product, such as coal, limestone, or other minerals. It simply flows from the ground, with no process of manufacture involved in its for-

mation, and no patentable form of composition, force or capability. It would, therefore, be strange indeed if our legislators intended natural gas to come within the scope of statutes governing the organization and specifying the privileges of manufacturing companies.

If the Engineers' Society of Western Pennsylvania were called upon to suggest on what points in connection with the subject of natural gas, legislation was desired, this committee would not hesitate to recommend for consideration, as follows:

First.—That a State Inspector of gas and artesian wells, and natural gas companies be appointed by the Governor, among whose duties we would specify: To report to the proper authorities, after due notice, any waste or extravagant use of natural gas, either at the wells or elsewhere, and that all natural gas companies be required to report to him the details of their operations, force and flow of the gas, and that all arrangements for its control at the wells, or in the pipes to a city, or borough line be under his general supervision. His office being compelled to keep up the records, and to report annually, with the aid of statistics and plans, the state of the natural gas supply and demand.

Second.—That in cities or towns, companies desiring to supply either manufacturers or domestic consumers with natural gas, may, with the consent of the councils thereof, and under the direction of the city or borough engineer, lay their pipes through or along any street, lane or alley, but no city or borough to have the right to give any exclusive privileges to any one gas company.

Awaiting the action of the State Legislature on the general matters which it might be expedient for that honorable body to consider, such as we have outlined above, your committee feel that they might be considered derelict in duty if they did not advise and propose, at least some measures which might be exercised by individual consumers of natural gas, tending both to security, as regards the dangers of fires and explosions, as well as to economy in its use.

We therefore would propose for the consideration of companies and individuals interested, the following:

First.—That the distributing mains for domestic consumption of natural gas be of size amply sufficient to conduct gas to dwellings with at no time or place a pressure exceeding 5½ inches (water pressure). This pressure can be guaranteed to be uniform, certainly never in excess, by a properly constructed form of tank governor.

Second.—Every domestic consumer of natural gas should see to it

that an automatic cut-off valve be placed on his service pipe, so arranged in case the supply from the tank governor should from any cause fail, that his valve would immediately close the pipe conducting to his premises, and requiring personal attention to restore the pressure when it again returns through the main. The committee believe that such automatic valves can be provided.

Third.—No cast-iron fittings, or parts of fittings of cast, or any coarse-grained or inferior metal, should be allowed in private houses. Carefully selected wrought-iron pipes, with brass or malleable iron fittings should alone be adopted. The great object of care being to prevent the possibility of leaks.

Fourth.—Special care should be taken to see that the street cut-off, or valve, is so boxed or tubed as to permit free outlet to the air of any gas escaping from a leaky main which may follow along the branch pipe from the street. The work of trenching to and tapping gas mains should be done when the frost is out of the ground, and the soil next the pipes in such trenches should be clay, well wetted and puddled.

Fifth.—In the case of fires under boilers, in ranges, fire-places, stoves, etc., consumers of natural gas have, for the most part, entirely disregarded its laws of combustion in not using the proper appliances for the admixture of air with the gas jets. In many instances, even among wholesale consumers of this fuel, it can be demonstrated that with the use of improved mixers the same quantity of heat as is now developed, can be produced from one-third the volume of gas.

Sixth.—The feed valves to fires, and all burners where natural gas is used in private houses should be securely placed so far above the floors as to be out of the way of children and where they could not be accidentally turned on. To this end valve stems with movable socket handles are of advantage.

Seventh.—All gas pipes laid from service mains should be thoroughly tested for leakage before being accepted as in working order.

Eighth.—Where natural gas is sold either entirely or as a component part of illuminating gas its candle power should be guaranteed to be of a satisfactory amount.

Respectfully submitted,

T. P. Roberts, F. C. Phillips,
A. E. Hunt, W. S. Jarboe,
N. M. McDowell,

Committee on Natural Gas.

ABSTRACTS OF REPORTS

OF THE BOARD OF EXAMINERS, INTERNATIONAL ELECTRICAL EXHIBITION OF THE FRANKLIN INSTITUTE.

[*Section No. 21.—Fire and Burglar Alarms and Annunciators.*]

EXHIBIT OF THE WESTERN ELECTRIC COMPANY.

The Hotel Fire Alarm and Room Call, exhibited by this company, is designed for the following purposes: When a call is received in the office by means of the annunciator, the clerk, by pressing one of the push buttons, can signify to the guest that the call has been received and will be attended to. Should the clerk desire to ascertain whether a guest is in his room, he can press on the proper button of the room call, and the guest, by pressing upon the button in his room, can signify that he is in. The room call can also be used to call the guests at any time desired; when employed for that purpose, the bell being kept ringing until the guest announces that he is both awake and up, by signaling back to the annunciator, causing the bell in the office to ring and his drop to fall. In case of a fire, by moving a switch, a crank is set in motion and rollers upon the two ends, by pressing upon the push buttons successively, ring the bell in every room.

The chief advantage claimed for this system is that it requires only the same battery as is in ordinary use for the hotel call, and it is therefore subjected to daily tests; but where a large battery is required for the fire alarm, there is a liability that, in time of a fire, from being seldom used, it will be found out of order. While there is quite a similarity in hotel annunciators, in this one the arrangements are novel and the mechanism simple in its construction, so as not to be easily disarranged.

In the Burglar Alarm Annunciator, the indications are made by means of the needle annunciator. By the action of suitably arranged switches it is possible to connect to or disconnect from the alarm, any part of the house, at pleasure; the annunciator and bell can be connected to the alarm if desired, or the annunciator can be connected and the bell not connected, thus giving a silent alarm; or to show whether the strength of the battery is sufficient to work the alarm, it can be connected with the bell alone.

By the system of "Continuous Ringing," the bell rings whenever an opening is made, not only as long as the opening remains but until attention is called to the alarm and the ringing stopped by means of the restoring apparatus. By means of a switch on each machine, the "Continuous Ringing" system can be used, or not, at pleasure.

The chief advantage claimed for the Williams Mechanical Gong is that it requires but a very slight electrical current to release the mechanism, and the hammer being near the centre of the shaft on which it swings, is easily set in motion, so that as it approaches the gong, the centrifugal force carries it into position.

For the Haskins Turtle Gong it is claimed that the pivoting of the armature is such that a very slight electrical current will be sufficient to actuate it. With this is combined the advantage of economy of space.

EXHIBIT OF THE NOVELTY ELECTRIC COMPANY.

The Novelty Electric Company exhibit the following Fire and Burglar Alarm systems:

The fire alarm exhibited was patented by Mr. Ahearn, of Ahearn & Soper, Toronto, Canada, and is designed as a cheap and economical system for small towns. Signal boxes are located at convenient points: these boxes are in electrical circuit with Bell Electro-Magnetos which are designed to be placed in engine houses, stores and private residences. The operation is simple and is as follows: The opening of the signal box door releases a weight, which, dropping, causes an armature to revolve between permanent magnets, which are similar in construction to the magnets and armature of the Bell magneto: this gives an effect the same as turning the crank of a magneto. On the spindle or the armature, or connected with it, is a small circular circuit breaker, which automatically signals the number of the station from which the signal has been sent upon all the bells with which it may be connected.

The burglar alarms exhibited were patented by D. Rosseau, of New York, and J. D. Lazelle, of New York, and contain the following important features: In addition to the alarm system, they have an attachment by which every door and window that is in circuit can be tested without the noise and annoyance of the bell ringing; this attachment is called a "silent tester." In the case there is also a clock which, besides being an ornamental time piece, automatically and

at any hour desired, opens all or any part of the house, and at the same time rings an alarm for the purpose of calling the occupants of a certain room.

Burglar Alarm, No. 2, has all of the above attachments, with additional attachments to awaken different servants, guests and household at different hours.

Burglar Alarm No. 3, in addition to the attachments of No. 1, has the advantage of a gas connection, which works in conjunction with indicators or drops, so that in case a burglar opens a door or window, he not only rings the bell and drops an indicator, but also lights the gas and reveals his exact position.

Burglar Alarm No. 4, merely communicates an alarm without giving any indications from what particular point it comes. In order to locate the point of alarm the switches must be turned on the face of the alarm, when the correct one will stop the ringing of the bell. The annunciators are of the shuttle-drop kind, not complicated nor easily put out of order, and are claimed to be effective.

APPLEGATE'S ELECTRIC FLOOR-MAT ALARM.

This system comprises essentially an electric alarm bell, a mat-carrying circuit, and closing and breaking devices, so that when the mat is subjected to pressure the alarm will be sounded. The mat consists of narrow strips of wood connected to a fabric backing, and on the strip side of the mat is a series of springs which support the mat, there being two separate wires and the springs being securely connected to each wire. When the mat is stepped upon these springs are compressed, contacts are made, and a current is sent through the connecting wires (which are embedded or grooved in the wood) to the bell electro-magnet, so as to sound an alarm. The bell has a switch or lever on the frame, by means of which, when moved, the vibrating adjustments are displaced and the current ceases to flow through the armature spring or circuit breaker, then passes directly through the magnet, and upon the movement of this switch or side lever, it greatly lengthens the stroke of the armature, which is essential when a single stroke only is desired. The same lever that lengthens the stroke switches the current directly through the magnet closing the circuit, attracting and holding the armature. The reverse movement of the lever readjusts the bell as a complete vibrator with a short stroke.

There is also a further improvement, "automatic," in the form of a ratchet wheel which revolves by the movement of the armature by means of a pawl, the wheel revolving upon a projection from the bell frame. The wheel has a pin, or pins, inserted and properly insulated from it. As the armature vibrates, the wheel revolves and one of the projecting pins comes in contact with two delicate springs sending the current directly through the magnet and holding the armature, acting automatically and giving a short sound of the alarm with the circuit still closed at the mat or other circuit-closing devices. When the circuit is broken at the mat it is also broken at the two small springs on the bell ready to repeat the short alarm upon closing the circuit, thereby preventing an annoyance while the distant points may be connected.

A padding is used, in connection with the mat or matting, comprised of four thicknesses of paper, glued together, known as carpet padding pulp paper. Each of the strips of different width; thus, by laying it at the outer edges, graduating the carpet and hiding the mat, and, in addition to the finish, preventing the mat from cutting the carpet or other covering.

The mat exhibited is intended for use on an open circuit, but can be used also on closed circuits.

The advantages claimed for this system are security, portability, cheapness and convenience. The mats may be placed beneath the carpet and the wires entirely concealed so that the burglar has no chance of rendering the device inoperative by cutting the wires, while a few pieces of the matting placed in different portions of the house would provide ample protection. The mat alarm affords the same protection, whether the doors or windows are closed or open, and therefore interferes in no way with the proper ventilation of the house. The system is available as a call for stores, offices, banks, etc., as well as for a burglar alarm. As the mat can be put down and taken up without trouble, and as the wiring is very simple, it can be readily transferred from one house to another. We append a copy of the patents which explain the accompanying diagrams.*

---

* Here follow copies of the drawings and specifications filed in the following patents: 195,074, September 11, 1877; 240,939, May 3, 1881, which the committee does not deem it necessary to re-publish.

EXHIBIT OF THE AMERICAN DISTRICT TELEGRAPH COMPANY.

The District Call system may be described as follows: A box contains a clock-work, which, when wound up, by the turning of a crank or handle on the outside of the box revolves a circuit-breaking wheel upon the periphery of which rests a connecting spring. When the crank or handle is placed at the word "messenger" and released, the revolution of the circuit wheel causes the connecting spring to drop into slotted or open spaces and breaks the main circuit and the signal of the box, thus arranged is received at the district or central office upon a relay, the back action of the armature of which closes a local circuit acting upon a bell and register and recording the signal. When the crank is placed at the word "police" and released, the circuit wheel makes two revolutions causing two registrations of the signal.

The several calls for which the box is arranged are determined by the number of times the signal is received at the central office.

It may be noted that all "call" signals end with an even figure to distinguish them from the burglar alarm signals which end with an odd figure. This system of calls being the usual method adopted by all District Telegraph Companies, for signaling from a distant point to a central office. No special claim is made for it excepting as it enters into the arrangement of the following described exhibits:

THE CLOSED CIRCUIT BURGLAR ALARM SYSTEM.

The doors and windows having been connected by closed circuit springs to the burglar alarm box placed in the building, the action may be substantially described as follows:

The box contains the circuit-breaking wheel before described, a pair of magnets to actuate an armature and a pivoted shaft to hold the circuit wheel in check. The main circuit is brought in and connected to each side of the pair of magnets,—after passing through the circuit wheel and connection spring, and, at these points the shunt or wire passing through the building and fastened to the spring, is also connected. When the shunt is closed by the closing of each and every door and window, the clock-work is wound up and the circuit wheel is caught and locked by the pivoted shaft, at the same time a plate drops in front of an opening in the box face and shows the word "set." The main circuit now passes from the point of connection over the

shunt, which offering a very much less resistance than the magnets cuts them out so long as the shunt is kept closed. Should any door or window now be opened, and the shunt be broken, the circuit passes through the magnets, attracting the armature which trips or throws off the detaining shaft and releases the clock-work. The magnets having performed their work, are, by a very simple device, cut out of the main circuit, and the circuit wheel and connection spring are alone left in the line circuit.

By the use of a simple device the magnets may be thrown into circuit, the box not being wound up, and should any portion of the shunt be open the armature will be attracted and a clicking sound be heard, which will not be possible if the shunt is closed and intact. The signal of the burglar alarm is transmitted five times. It is claimed that this system is a perfect closed circuit "alarm," by which it is not possible to leave any portion of a building, connected by this method, open or unprotected, as the shunt must be closed in its entirety to wind up and "set" the alarm box.

The protective or cabinet system consists of a wooden case or covering, the inner surfaces of which are lined throughout with wires, which, being securely fastened in both directions upon the surfaces, forms a perfect protection. This case may be used as a cabinet, simply, or as an enclosing case for a safe. It is connected by wire with a central office having special appliances for receiving notice of the closing as well as the opening of the case. It is claimed for this system that it is a perfected method of protecting safes, vaults and rooms by an electric covering which cannot be broken through, cut out of circuit, or in any manner tampered with, after having been closed and placed in connection with a central office, by any one—expert burglar, electrician, or any other person.

THE POLICE SIGNAL SYSTEM OF THE MUNICIPAL SIGNAL COMPANY OF BOSTON.

This system provides means of intercommunication between the policemen on their routes and the commanding officer at the police station, by signaling apparatus designed for the purpose and also by telephone, the latter being used solely as an adjunct to the signaling portion of the system. The exhibit comprises a station house apparatus and a policeman's beat equipped with two signal boxes or stations

and a telephone station, the stations being connected with the station house instruments by two metallic circuits, one for signals and the other for telephones. The station house instruments consist of two relays, one on each side of the signal circuit, their armatures controlling two ink recorders after the manner of district or fire alarm telegraphs. One of these recording instruments registers the "on duty," or "patrol" signals of the policemen, while the other only records the "alarm" signals. The signals are regulated by the introduction of a greater or less resistance, the less resistance being used for the patrol and the greater for the alarm signals. The station house is also provided with a transmitter capable of transmitting any one of a hundred numbers, and it is provided with an index dial and pointer for convenience in setting it in position to transmit any desired number. The transmitter itself is of ingenious construction, being a concaved drum, having the circuit controlling contact points for each number grouped thereon longitudinally, the various signals being arranged side by side round the drum. Four revolving arms, moved by a clock-work motor, controlled by detents and having flexible contacts at their extremities, which, when revolved, successively co-operate with the contact points on the concave surface of the drum, close and open a local circuit controlling a pole changer whereby the main battery on the signal circuit is reversed whenever the revolving contact in co-operation with one of the drum contacts, closes the local circuit of the pole changer. The street signal boxes, when their doors are open, expose dials having nine different signals or calls conspicuously displayed thereon, such as "Aid," "Wagon," "Riot," "Ambulance," etc., and should a policeman require "aid," "wagon," or anything inscribed on the dial, he has merely to move an index finger to that desired, and then give the alarm, which causes characters, such as dots and dashes to be transmitted over the circuit and recorded at the police station, indicating to the person in attendance the nature of the aid and the locality where it is wanted. The closing of the door of the signal box restores the indicator to its normal position. Citizens may have keys issued to them, numbered and registered at police headquarters, and they can give a police alarm from any signal station by merely inserting the key in a "citizen's keyhole," underneath the door of the signal box, turning it as far as it will go, and then releasing it, and a policeman can likewise, in an emergency, give a call for

assistance in like manner, without being obliged to open a door of any kind.

The telephone stations, as shown in this exhibit, are separate from the signal stations, but they each bear a number to distinguish them from each other, as do also the signal stations. It is claimed that the telephone stations can be combined with the signal stations.

Policemen can send in their "on duty" signal from the signal boxes in rotation, at certain definite times, and these signals are received on the patrol register at the police station, and, at the same time, the transmitter is automatically brought into action and transmits over the circuit whatever number is in position for transmission, ringing it on a bell inside of the street signal box, by means of a polarized magnet and armature, the policeman being informed by the number he hears whether he is wanted at the telephone or at some other signal station.

The chief merits claimed for this system are: complete control of the policemen by their commanding officer; rapid and efficacious communication of policemen and citizens with police stations, and separate and independent recording instruments for alarms and "on duty" signals on a single circuit. It is also claimed that if an "on duty" signal and a "call" signal be given simultaneously that the "call" signal will be registered notwithstanding the "on duty" signal, the interference not affecting the more important, or "call" signal, owing to the higher resistance introduced into the circuit.

The mechanism by means of which the signal boxes are operated was not shown to the committee.

THE PORTER AUTOMATIC ELECTRIC SIGNAL AS A FIRE ALARM SYSTEM.

The principle of the circuit is known as the earth or ground connections; that portion, however, which is outside of the office is metallic, the grounded ends being under control of the operator at the station.

At each end of the circuit there is a system of relays and local signal. On one of the ends there is a rheostat for the purpose of increasing or diminishing the resistance of the circuit. The ordinary method for using this is to "put in" as much resistance on the rheostat end of the circuit as will enable the tension spring of the relay at the outgoing end of the circuit to overcome the magnetic attraction on the armature, thus holding it away from the poles until the resistance in

the circuit is reduced when the magnetic attraction will overcome the tension spring and a local alarm is the result. The relay on the rheostat end of the circuit is operated just the reverse of the one at the battery end, the adjustment being made so that the magnetic attraction barely overcomes the tension spring; so that the slightest falling off of magnetic attraction will permit the tension spring to draw the armature back, when the other local alarm system will be operated.

Each signal box has an earth connection, which is brought into use only when the box is operated so that, by giving a signal, a ground is established through the circuit breaking wheel, the circuit being broken by the same operation, as the wheel revolves, the combination giving the number of the box is consecutively made and repeated three times. It is claimed for this system of signaling that on one side the circuit might be entirely destroyed, while the signal would come into the office all right on the other side. It is also claimed that the operator is made aware of the slightest changes in the condition of the circuit and without leaving his station can instantly switch in a reserve battery or even utilize a "ground," "break," or "cross" to do the work of signaling.

EXHIBIT OF PARTICK & CARTER.

The novelty of device, mechanism, etc., which is claimed for the annunciators and alarms in the above exhibit, are:

1. A perforated zinc plate acting as a dial and support for the pointers, and in the smaller size performing the part of tripping or restoring mechanism without any farther mechanism being necessary than a pair of hinges at the top of plate. The plate, or dial on being moved forward, breaks the contact between the pointer and the magnet core; no amount of jar or hard usage will throw this plate out of place or adjustment, a very important point when the rough handling of kitchen and other annunciators is so apt to throw delicately constructed mechanism out of order.

2. The small number and great simplicity of the parts, there being only one magnet and a pivoted needle or pointer necessary for each indicator or number, thus reducing the number of parts to a minimum, the simple pointer doing the work of several parts.

3. In the large or hotel annunciators the same mechanism is employed as in the smaller, with the exception that the dial is stationary,

the tripping mechanism being merely a system or number of brass strips carrying pins projecting through slots in the dial. These pins press the pointer away from the magnet core whenever the trip handle is moved. Only the pointer that is indicating is moved by this arrangement.

4. Owing to the extreme simplicity of this apparatus a very small battery power is required to operate the annunciator.

5. All bells placed in these annunciators are mounted on iron frames, so arranged that it is almost impossible to put them out of adjustment.

6. The needle or pointer can be made of steel or iron, as permanent magnetism is not depended upon to cause it to adhere to the core of the magnet, residual magnetism being sufficient.*

The committee regret that they were not furnished with more lettered diagrams of the exhibits as thereby the explanations could have been more clearly set forth.

In some instances it was found that the persons in charge of the exhibits were not as fully competent to explain the workings thereof as the committee would have desired.

[SIGNED.]

DAVID R. WALKER, *Chairman.*

WM. ATLEE DRYSDALE, HUGO BILGRAM,
DAVID BROOKS, LOUIS H. SPELLIER,
E. ALEX. SCOTT, THEO. D. RAND.

ENDLESS WIRE SAW.—M. Vialatte has invented a new saw for stone-cutting. It consists of an endless metallic cord composed of one or more soft steel wires, twisted together and subjected to a continuous movement in a uniform direction, and fed with siliceous sand or grit. The sand is mixed with water, as in ordinary stone-sawing, in order to facilitate its penetration to the bottom of the crevice and to prevent heating. The apparatus can be easily set up, taken down, or transported from place to place, and one of its great advantages is the readiness with which it can be used in quarries, so as to avoid superfluous transportation. Tissandier speaks of it as "the butter-cutting wire, used for sawing stones."—*La Nature*, May 17, 1884. C.

---

* Here follows diagram of connection for the Patrick & Carter alarm, which the committee do not think it necessary to reproduce.

CORRESPONDENCE.

Committee on Publication of the Journal of the Franklin Institute:

GENTLEMEN:—In the February number of the JOURNAL for 1882, I gave to your readers a paper upon a "New Theory of the Suspension System with Stiffening Truss." In that paper I advocated the use of a truss fixed horizontally at the ends and continuous at the centre, and gave the mathematical discussion of such a truss, so far as I know, for the first time. Previous writers have assumed that the curve of the cable for a partial loading remains unchanged, such a partial loading being distributed over the cable by means of the truss, and the cable therefore retaining its parabolic shape. This assumption I repudiated, and introducing instead of it the condition that the *horizontal pull* of the cable remains practically the same as if its form were unchanged, I applied the received theory of flexure to this system, and as I think, completely solved the case. I need hardly say that no such structure as yet exists, to my knowledge, as such a suspended truss, and I put forward the combination as a new one, which would be found stiffer than any of the known forms of suspension, and which could by means of my formulæ be completely calculated.

I have just received a letter from C. B. Bender, C. E., member American Society of Civil Engineers, from England, enclosing a hectograph copy of a paper upon "Suspension Bridges of any Desired Degree of Stiffness," written by him May 28, 1881, upon which he claims priority for the theory. This paper I had never seen, and my solution was independently made; still it is but simple justice to Mr. Bender, and it is the object of this communication to state to all interested, that so far as the *general method* of solution is concerned, by the application of the theory of flexure to the suspension system in such a way as to avoid the incorrect assumption hitherto made, Mr. Bender's claim of priority is fully made out. As the entire originality of the discussion from a mathematical standpoint, lies in this, such credit as there is in it belongs to him.

So far as my treatment of the special case supposed, *i. e.*, ends horizontally fixed and centre continuous, is concerned, it still remains the only solution I know of. This solution is but a special case of Mr. Bender's more general discussion, however, and one which he might easily have made had he chosen so to do. The special case to which he di i apply his method, was that of a stiffening truss *hinged at the centre* and *supported at the ends*. Our actual solutions, therefore, are widely different. This much is due to myself, as, owing to the fact that Mr. Bender is about to bring out a work which will contain his theory, and his undoubted claims to priority in the general method, as well as the similarity of much of the notation employed, I might otherwise be placed in an unenviable position.

Yours very truly,

A. J. DU BOIS.

NEW HAVEN, CONN., November, 1884.

Book Notices.

TESTING MACHINES; THEIR HISTORY, CONSTRUCTION AND USE. By Arthur V. Abbott. New York: D. Van Nostrand, 1884.

But few engineers have opportunities equal to those of the author, for acquiring practical experience in the modes of testing the strength of the various materials used in architectural structures and works of engineering, and a compilation of such experience cannot fail to be of considerable value to all engineers. The author has, indeed, in the above-cited concise treatise, done full justice to the task he has undertaken.

After giving a brief sketch of the history of testing machines, he describes a number of such machines, as produced by various makers, giving his views of the merits and demerits of the same, without fear or favor. He then describes and analyzes the phenomena attending the tests of various materials, giving to others the benefit of his labor and experience.

H. B.

THE PHILADELPHIA INSURANCE CHART FOR 1884–1885. By J. H. C. Whiting. Philadelphia: Review Publishing and Printing Co.

This annual insurance chart, which this year appears in convenient pocket-book form, is a model of condensed information in regard to the specialty insurance. It contains a complete directory of all insurance companies, and insurance agencies and brokers doing business in Philadelphia. Part of the value of this work is a compendious table of Philadelphia fires for the decade 1874–1883, thoroughly classified, and giving the number, amount of losses and insurance, with the percentages of losses. This chart also contains much valuable local information of a miscellaneous character.

N.

ELEMENTARY TEXT-BOOK ON PHYSICS. By Prof. Wm. A. Anthony and Prof. Cyrus F. Brackett. New York: John Wiley & Sons, 1884.

A text-book that gives in concise language and logical sequence the modern ideas of physics, unencumbered with obscure mathematical expressions that place it beyond all but a limited class, has long been needed. It is fortunate for the student of physics that gentlemen so capable as the authors have been willing to undertake the work, and we heartily congratulate them on the result. They have placed before the general public, as well as the average college student, a clear, fresh, and accurate work on physics, that will acquaint its readers with the latest developments of the science. The book is the work of scholarly minds, trained in the art of teaching. Throughout its pages expressions and methods of presentation of ideas abound, that bear the impress of the practical teacher.

The book is not wanting in the necessary application of mathematics to the solution of physical principles. It will, indeed, necessitate on the part of the student a thorough mathematical training in algebra, geometry and

plane trigonometry, and, indeed, in some few cases, in analytical geometry, though these last may be omitted without serious lack of continuity.

Part I of the work, which is before us, contains 246 pages. It gives in its introductory matter, concise, illustrated descriptions of apparatus used in the measurements of space and time. Chapter I, treats of the Mechanics of Masses. Chapter II, of Universal Attraction. Chapter III, of Molecular Mechanics, and Chapter IV, of the Mechanics of Fluids. This chapter completes Book I.

Book II which completes this part of the work, is devoted to the consideration of the production and nature of Heat. In it will be found full explanations of the modern ideas of heat. The closing chapter on Thermo-Dynamics is especially to be commended.

Part II will include the subjects, Electricity and Magnetism, Acoustics and Optics.

We regret that the value of this book should have been impaired by the absence of an index. We believe, however, that the authors intend placing an index at the end of the completed work. E. J. H.

Franklin Institute.

[*Proceedings of the Stated Meeting, held Wednesday, December* 17, 1884.]

HALL OF THE INSTITUTE, December 17, 1884.

MR. WILLIAM P. TATHAM, President, in the Chair.

Present, 138 members, and 11 visitors.

Twenty-one (21) persons were elected members of the Institute since the November meeting.

The following nominations for officers, to be chosen at the annual meeting in January, were made:

For President (to serve one year), William P. Tatham.

For Vice-President (to serve three years), Joseph E. Mitchell.

For Secretary (to serve one year), William H. Wahl.

For Treasurer (to serve one year), Samuel Sartain.

For Managers (to serve three years; eight to be chosen), William Sellers, J. Vaughan Merrick, Hector Orr, William D. Marks, Cyrus Chambers, Jr., Charles J. Shain, Henry R. Heyl, Hugo Bilgram, G. Morgan Eldridge, Charles E. Ronaldson, M. B. Snyder.

For Auditor (to serve three years), William B. Cooper.

For Representative in the Pennsylvania Museum and School of Industrial Art, William H. Wahl.

Mr. W. Barnet LeVan presented a series of views, exhibiting the time tables of the fastest trains on the principal European and American railways, and commented upon the same. An abstract of Mr. LeVan's remarks has been referred to the Committee on Publication.

The Secretary, in his report, made some further references to the experiment of purifying the Schuylkill water by aëration, in connection with which, he presented a communication from Col. William Ludlow, Chief of